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Asteroids, the New Western Frontier: Applying Principles of the General Mining Law of 1872 to Incentive Asteroid Mining

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ASTEROIDS, THE NEW WESTERN FRONTIER: APPLYING PRINCIPLES OF THE GENERAL MINING LAW OF 1872 TO INCENTIVIZE ASTEROID MINING

LAUREN E. SHAW*

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ABSTRACT

THE GRANTING OF a property right has been an effective method to incentivize individuals to take on costly, time consuming, and even dangerous ventures. These ventures, such as the extraction of coal, gas, and oil from uncharted America back in the 1800s, have led to developments that greatly benefit society. Today, technology has advanced to the point where one of the next costly, time consuming, and dangerous, yet potentially advantageous, undertakings is asteroid mining. But there is currently no law that directly addresses what rights a miner would have in resources extracted from an asteroid. While many have argued about the legalities of mining asteroids or the Moon under existing laws and treaties, few have considered the necessity of having a property right scheme in place before such missions come to fruition. Without certainty in what property rights exist in the extracted resources, the incentive to extract these resources will be greatly diminished. This situation is similar to the mining situation in the Western Frontier in the early 1800s, which is why this article proposes that a property right

scheme modeled after the General Mining Law of 1872 should be applied in the context of asteroid mining.

I. INTRODUCTION

To some, the mining of asteroids might sound like the premise of a science fiction novel¹ or the solution to the heart-wrenching, fictional scenario depicted in the film *Armageddon*.² To others, it evokes a fantastical idea that may come to fruition in a distant reality. However, impressively funded companies have plans to send spacecraft to begin prospecting on asteroids within the next two years.³ The issues associated with the mining of asteroids should be addressed before these plans are set in motion.

Much has been written about the issues that might arise from allowing nations to own these space bodies and the minerals they contain; one such issue is the impact on international treaties.⁴ However, little has been written about the applicability of

¹ In fact, many science fiction novels have incorporated asteroids as new frontiers into their plots or even involved mining of asteroids as a critical part of the economy in a futuristic setting. See, e.g., C. J. CHERRYH, *HEAVY TIME* (1992); JACK WILLIAMSON, *SEETEE SHIP* (1951).

² *ARMAGEDDON* (Touchstone Pictures 1998) (A fictional film about an asteroid the size of Texas on route to impact Earth and potentially obliterate all of its inhabitants. To stop this asteroid, NASA partners with a misfit crew of oil drillers and geologists to explode a large nuclear weapon inside the asteroid and throw it off its deadly trajectory.).

³ Ned Potter, *Mining Asteroids: The Real Story from Planetary Resources, Inc.*, ABC NEWS (Apr. 24, 2012), <http://abcnews.go.com/Technology/mining-asteroids-real-story-planetary-resources-space-startup/story?id=16197612>. Eric Anderson, who is already experienced in commercial space flight ventures, co-founded the well-funded Planetary Resources, Inc. and recently claimed that a launch by Planetary Resources, Inc. to begin prospecting asteroids could happen in as little as eighteen months to two years. *Id.*

⁴ Some authors have discussed property right schemes for governing natural resources in space. However, they typically propose complex new systems of international law. See, e.g., Sarah Coffey, Note, *Establishing a Legal Framework for Property Rights to Natural Resources in Outer Space*, 41 CASE W. RES. J. INT'L L. 119, 144–47 (2009) (suggesting a new proposal for governing property rights to outer space resources through a system of credits allocated among nations through various international treaties and United Nations agreements); Jeremy L. Zell, Note, *Putting a Mine on the Moon: Creating an International Authority to Regulate Mining Rights in Outer Space*, 15 MINN. J. INT'L L. 489, 518–19 (2006) (proposing the creation of a “Space Resource Authority” to “create economic incentive for nations and firms to simultaneously invest in outer space and developing nations”). This article seeks to take an existing law, the General Mining Law of 1872, which is a more basic property right scheme, and show its applicability to the context of mining natural resources in space to show how a more simple solution might exist.

preexisting mining laws—which provide a basic property right scheme for the private sector—such as the General Mining Law of 1872 (Mining Law) to the management of asteroid mining.⁵ The literature to date on how to legally address asteroid mining is minimal.⁶ The articles that do address it propose the creation of different systems, such as a “property rights-based system that relies on the doctrine of first possession”⁷ or an international authority that would regulate mining operations.⁸ Implementing a scheme that offers ownership of extracted resources without bestowing complete sovereignty is necessary to avoid an impending legal limbo—that is, an outer space “Wild West” equivalent where there is neither certainty nor security in who owns what.⁹ If private sector miners of asteroids know this right already exists, they will have more incentive to extract resources.¹⁰ This, in turn, would increase the chances of successful missions, resulting in numerous scientific and explorative benefits, along with the potential replenishment of key elements that are becoming increasingly depleted on Earth yet are still needed for modern industry.

⁵ See generally Kevin V. Cook, Note, *The Discovery of Lunar Water: An Opportunity to Develop a Workable Moon Treaty*, 11 GEO. INT’L ENVTL. L. REV. 647 (1999); Brandon C. Gruner, Comment, *A New Hope for International Space Law: Incorporating Nineteenth Century First Possession Principles into the 1967 Space Treaty for the Colonization of Outer Space in the Twenty-First Century*, 35 SETON HALL L. REV. 299 (2004); Matthew Johnshoy, Note, *The Final Frontier and a Guano Islands Act for the Twenty-First Century: Reaching for the Stars Without Reaching for the Stars*, 37 J. CORP. L. 717 (2012); David Johnson, Comment, *Limits on the Giant Leap for Mankind: Legal Ambiguities of Extraterrestrial Resource Extraction*, 26 AM. U. INT’L L. REV. 1477 (2011); Zell, *supra* note 4.

⁶ See sources cited *supra* note 5.

⁷ Gruner, *supra* note 5, at 306.

⁸ Zell, *supra* note 4, at 492.

⁹ See Johnshoy, *supra* note 5, at 719 (“Unfortunately, current space law is undeveloped and may be ill-suited to incentivize and protect the interests of companies willing to invest in the exploration and industrial development of outer space.”); see also Michael J. Listner, *The Ownership and Exploration of Outer Space: A Look at Foundational Law and Future Legal Challenges to Current Claims*, 1 REGENT J. INT’L L. 75, 94 (2003) (recognizing that “[w]hen someone breaks the technological barriers to make space travel affordable, practical, and profitable, we will find ourselves playing catch-up in dealing with the explosion of legal challenges that will arise” and acknowledging that we are on the brink of breaking those barriers).

¹⁰ Johnshoy, *supra* note 5, at 719 (quoting Brian M. Hoffstadt, Comment, *Moving the Heavens: Lunar Mining and the “Common Heritage of Mankind” in the Moon Treaty*, 42 UCLA L. REV. 575, 577–79 (1994)) (“The most important factor may be the creation of a ‘stable legal environment’ that allows for ‘the retention of profits and the prevention of technology transfer.’”).

Scientists speculate that key elements needed for modern industry, including platinum, zinc, copper, phosphorus, lead, gold, and indium, could become depleted on Earth within the next fifty to sixty years.¹¹ Many of these metals, such as platinum, are chemical elements that, unlike oil or diamonds, have no synthetic alternative.¹² Once the reserves on Earth are mined to complete depletion, industries will be forced to recycle the existing supply of minerals, which will result in increased costs due to increased scarcity.¹³

However, evidence is accumulating that asteroids only a few hundred thousand miles away from Earth may be composed of an abundance of natural resources—including many of the minerals being mined to depletion on Earth—that could lead to vast profits.¹⁴ Most of the minerals being mined on Earth, including gold, iron, platinum, and palladium, originally came from the many asteroids that hit the Earth after the crust cooled during the planet's formation.¹⁵

Considering the recent developments in private space exploration and the increasing interest of investment groups in continuing to fund it, space has become the new “Western Frontier.”¹⁶ Some space exploration groups have decided to fo-

¹¹ David Cohen, *Earth's Natural Wealth: An Audit*, NEW SCIENTIST, May 23, 2007, at 34–41, available at http://www.science.org.au/nova/newscientist/027ns_005.htm.

¹² *Id.*

¹³ “Scarcity is perhaps the most basic feature of any natural resource conflict, for the simple reason that if the resource were not scarce there would be no need for law, i.e., there would be plenty to go around.” JAMES RASBAND ET AL., NATURAL RESOURCES LAW AND POLICY 36 (2d ed. 2009). With scarcity, not only do costs increase due to greater demand than supply, but battles between competing interests also arise over the proper and most efficient uses of the resource. *Id.* at 36–37.

¹⁴ Listner, *supra* note 9, at 75–76.

¹⁵ *Geologists Point to Outer Space as Source of the Earth's Mineral Riches*, SCI. DAILY (Oct. 19, 2009), <http://www.sciencedaily.com/releases/2009/10/091018141608.htm>; see also James M. Brennan & William F. McDonough, *Core Formation and Metal-Silicate Fractionation of Osmium and Iridium from Gold*, NATURE GEOSCIENCE 1 (Oct. 18, 2009), <http://www.geology.utoronto.ca/Members/brenan/Brenan%20and%20McDonough,%202009.pdf> (explaining that asteroids potentially had a significant role in the formation of Earth's crust and were likely the source of many minerals due to their collision with Earth while it was forming).

¹⁶ See Listner, *supra* note 9, at 75–76 (“Only a few hundred thousand miles beyond the surface of the Earth [is] an abundance of natural resources waiting for someone to harvest. The exploitation of these resources and the prospect of colonizing other worlds, once the exclusive subject of science fiction, [are] moving cautiously towards reality.”).

cus on colonizing space, while others are taking a more economic view of space as a vast, untouched source of minerals and gases to be extracted.¹⁷ Either focus—colonization or economic extraction—will open up opportunities for extensive technological development.

As discussed below, property rights have long created incentives to exploit and explore. This article applies the existing property rights structure from the Mining Law in the context of asteroid mining.¹⁸ This article proposes that the Mining Law would serve as an appropriate and effective model in the context of asteroid mining. This model would offer certainty and security in the select rights obtained without granting complete sovereignty, thus avoiding excessive international upset.¹⁹ The model would also impose minimal transfer costs on the miners and provide a means of recordation and dispute resolution.²⁰

Section II begins by explaining the status of the private sector's mining pursuits in space and why these pursuits should be encouraged. It explains that private companies are coming increasingly close to being able to mine asteroids and that some certainty and structure needs to be in place *before* these private companies are able to reach the asteroids. Section III presents the motives to mine asteroids, the current methods of incentiviz-

¹⁷ Several of the private companies seeking to commercialize space are discussed in more detail below. As mentioned already, Planetary Resources, Inc. is one of the private companies seeking to mine asteroids within the next few years. PLANETARY RESOURCES, www.planetaryresources.com (last visited Apr. 5, 2013). There are also other plans centered on colonizing space, such as Virgin Airlines CEO Richard Branson's plans to colonize Mars. *Richard Branson on Space Travel: "I'm Determined to Start a Population on Mars"*, CBS NEWS (Sept. 18, 2012), http://www.cbsnews.com/8301-505263_162-57514837/richard-branson-on-space-travel-im-determined-to-start-a-population-on-mars.

¹⁸ See 30 U.S.C. §§ 21–54 (2012).

¹⁹ Recognizing that there will be considerable international political consequences in applying such a law, the details of these consequences in relation to existing international treaties and relationships between nations are beyond the scope of this article and have been recognized in other articles. See generally Listner, *supra* note 9; Gbenga Oduntan, *Imagine There Are No Possessions: Legal and Moral Basis of the Common Heritage Principle in Space Law*, 2 MANCHESTER J. INT'L ECON. L., no. 1, 2005, at 30.

²⁰ Discussed in more detail later, these transfer costs would be comparable to those in the Mining Law and would require a *de minimis* payment to the government along with a filing fee and possible survey fee. Like the Mining Law, this would only be a *de minimis* fee on the face of the law because there would still be great expense involved in locating minerals in the first place, prior to staking a claim. Andrew P. Morriss et al., *Homesteading Rock: A Defense of Free Access Under the General Mining Law of 1872*, 34 ENVTL. L. 745, 758 (2004).

ing their mining, and the present state of agency involvement. It provides a snapshot of the status today, revealing the shortfalls of our current system's ability to incentivize commercial space ventures. Section IV covers a brief history of mining laws in the United States leading up to the Mining Law, a summary of this law, and a brief evaluation of its effectiveness, consequences, and limitations. This section's historical overview clarifies why the Mining Law is the best model for the present asteroid mining situation. Finally, Section V provides a section-by-section analysis of the Mining Law and how each section could be applied and adapted to a mining law concerning asteroids, along with an analysis of the agency involvement that would be required.

Asteroid mining will soon become a reality. Hence, it is necessary to have laws in place that provide structure and clarify what rights private investors will have once they reach the asteroids and how these investors can attain and maintain those rights. This structure is necessary both to incentivize the private sector to make the large initial investment necessary to complete such an endeavor and to avoid incredibly expensive conflicts between companies and nations over who owns what. Implementing an asteroid mining law based on the Mining Law will provide that necessary structure.

II. THE PRIVATE SECTOR AND MINING ASTEROIDS

The private sector has stronger financial support and is thus more equipped than the public sector to take on space mining ventures.²¹ However, the public sector would still have considerable involvement due to its ability to regulate such endeavors. Accordingly, this section briefly explains why the private sector is better suited to conduct space mining ventures. It provides some details about several private sector companies that currently have serious ambitions to accomplish mining in outer space in the near future. This section concludes with an explanation of why the public sector needs to provide some sort of regulatory structure to make private investment worthwhile.

In the United States, funding for public space programs through the National Aeronautics and Space Administration

²¹ This section will explain the decreasing financial support from the U.S. public sector and how the private sector has the funds and willingness to take on asteroid mining ventures.

(NASA) has decreased dramatically over the past twenty years.²² Presently, it is at its lowest percentage of the federal budget since 1960.²³ While public spending has been decreasing, private spending has been increasing.²⁴ Private companies have been involved in launching commercial satellites into space since before a man walked on the Moon.²⁵ Today, the private sector focus has expanded to other commercial space ventures, including the mining of celestial bodies, and several private firms have already formulated financially backed plans to accomplish these ventures.²⁶

Planetary Resources, Inc. is one group of investors that has already taken considerable steps toward mining asteroids.²⁷ Planetary Resources is supported by a team of individuals who "have landed spacecraft on Mars, started new industries, and fi-

²² Simon Rogers, *NASA Budgets: US Spending on Space Travel Since 1958 Updated*, GUARDIAN DATA BLOG (Feb. 1, 2010, 5:52 AM), <http://www.guardian.co.uk/news/datablog/2010/feb/01/nasa-budgets-us-spending-space-travel> (citing *Historical Tables*, OFF. OF MGMT. & BUDGET, <http://www.whitehouse.gov/omb/budget/Historicals/> (last visited Mar. 7, 2013)).

²³ *Id.*

²⁴ The Space Foundation's 2012 report on global space-industry growth revealed 12.2% growth in the global space industry and attributed most of that growth to private commercial growth, noting that "[c]ommercial space companies' stocks also out-performed the marketplace in 2011." *Space Foundation's 2012 Report Reveals 12.2 Percent Global Space Industry Growth in 2011*, SPACE FOUND. (Apr. 5, 2012), <http://www.spacefoundation.org/media/press-releases/space-foundations-2012-report-reveals-122-percent-global-space-industry-growth>.

²⁵ "On July 20, 1962 the Telstar I satellite was launched for the American Telephone and Telegraph Company with an expendable Delta launch vehicle. It was the first satellite owned by private enterprise." George S. Robinson, *Private Management and Operation of the Space Shuttle: Some Legal Problems Related to Market Entry*, 13 AKRON L. REV. 601, 609 (1980). NASA put a man on the Moon on July 20, 1969, with the Apollo 11 mission. Steve Garber & Roger Launius, *A Brief History of NASA*, NASA HIST. PROGRAM OFF., <http://history.nasa.gov/factsheet.htm> (last updated July 25, 2005).

²⁶ Several of these firms are discussed in more detail below.

²⁷ *Plans for Asteroid Mining Emerge*, BBC NEWS (Apr. 24, 2012), <http://www.bbc.co.uk/news/science-environment-17827347>; Irene Klotz, *Tech Billionaires Bankroll Gold Rush to Mine Asteroids*, REUTERS (Apr. 24, 2012), <http://www.reuters.com/article/2012/04/24/us-space-asteroid-mining-idUSBRE83N06U20120424>; see also Peter Suci, *Asteroid Mining Venture Could Change Supply/Demand Ratio on Earth*, RED ORBIT (Apr. 28, 2012), <http://www.redorbit.com/news/space/1112523850/asteroid-mining-venture-could-change-supplydemand-ratio-on-earth/> (discussing how an endeavor to mine asteroids that results in precious metals being brought back to Earth could shift the supply and demand of such metals, using gold as a primary example; the price of gold, "which hovers around \$1500 an ounce" and does not have a large supply to begin, could be driven down drastically if a large source is found on an asteroid and brought back to Earth).

nanced some of the most unique and exciting companies of our time.”²⁸ Planetary Resources’ present goal is to create low-cost robotic spacecraft to explore asteroid candidates and process their resources for subsequent campaigns.²⁹ To get closer to attaining this goal, Planetary Resources recently formed “an agreement with Virgin Galactic, LLC that will enable multiple launch opportunities for its series of spacecraft.”³⁰ After achieving its prospecting goals, Planetary Resources seeks to use water from asteroids to “fuel the in-space economy” and mine rare metals that “will increase Earth’s [Gross Domestic Product (GDP)].”³¹

Another company with plans to conduct mining expeditions in outer space is Moon Express, Inc.³² Moon Express is a leading contender in the \$30 million Google Lunar X PRIZE competition,³³ challenging “privately funded teams to place a robot on the Moon’s surface that transmits high definition video, images[,] and data to Earth from the landing site and from 500 meters away.”³⁴ Moon Express “plans to send a series of robotic spacecraft to the Moon for ongoing exploration and commercial development focused on benefits to Earth and has signed a partnership agreement with NASA for development of a lunar lander system.”³⁵

A third company, Shackleton Energy Company, wants to be the first to successfully mine the Moon for ice to provide propel-

²⁸ *Team*, PLANETARY RESOURCES, <http://www.planetaryresources.com/team/> (last visited Mar. 7, 2013).

²⁹ *Mission*, PLANETARY RESOURCES, <http://www.planetaryresources.com/mision> (last visited Mar. 7, 2013).

³⁰ See *Planetary Resources, Inc. Announces Agreement with Virgin Galactic for Payload Services*, PLANETARY RESOURCES (July 11, 2012), <http://www.planetaryresources.com/2012/07/planetary-resources-inc-announces-contract-with-virgin-galactic-for-payload-services/> (explaining that these endeavors include the Arkyd-100 low-Earth-orbit space telescopes for prospecting on asteroids).

³¹ *Mission*, *supra* note 29.

³² MOON EXPRESS, <http://www.moonexpress.com> (last visited Mar. 7, 2013).

³³ The Google Lunar X PRIZE is one of the many prizes offered by the X PRIZE Foundation, which will be discussed in more detail below. *Prize Details*, GOOGLE LUNAR X PRIZE, <http://www.googlelunarxprize.org/prize-details> (last visited Mar. 7, 2013).

³⁴ Bob Richards, *Moon Express, Inc. Announces Acquisition of Next Giant Leap, LLC*, GOOGLE LUNAR X PRIZE (May 30, 2012, 9:52 AM), <http://www.googlelunarxprize.org/teams/moon-express/blog/moon-express-inc-announces-acquisition-next-giant-leap-llc>.

³⁵ *Id.*

lant for planetary missions.³⁶ Shackleton has begun fundraising and has established a team of explorers, engineers, robotic mining experts, aerospace managers, economists, and space policy lawyers.³⁷ Bill Stone, the founder of Shackleton, has another company, Stone Aerospace, which was “the recipient of a \$4 million, four-year NASA contract to develop an ice-drilling robotic probe that would be used to obtain samples from Jupiter’s moon[,] Europa.”³⁸ However, due to recent cuts to the NASA budget, that project is now on indefinite hold.³⁹

The technology necessary for any of these or similar ventures to succeed is developing rapidly, and the costs are decreasing considerably. For example, Space Exploration Technologies (SpaceX) recently returned its reusable Dragon cargo capsule to Earth from the International Space Station (ISS) after Dragon delivered critical cargo to the ISS.⁴⁰ Developments in reusable spacecraft, in tools used for gathering data on the material compositions of space bodies, and in alternative means of obtaining fuels, such as the ability to refuel at orbital propellant depots, are all presently multiplying, thereby driving down the costs of exploring and commercializing space.⁴¹

While it is not presently cost effective to mine asteroids,⁴² these developments in technology and the increasingly certain

³⁶ Duncan Geere, *Shackleton Energy Wants to Be the First to Mine the Moon*, WIRED (Nov. 18, 2011), <http://www.wired.co.uk/news/archive/2011-11/18/moon-mining>.

³⁷ *Id.*

³⁸ Carl Franzen, *Another Space Mining Company Still Struggling to Get Off the Ground*, TPMIDEALAB (Apr. 24, 2012), <http://idealab.talkingpointsmemo.com/2012/04/just-another-space-mining-company.php>.

³⁹ *Id.* As mentioned above, lack of funding to support government projects is a primary reason to support and incentivize the private sector to head space commercialization ventures.

⁴⁰ Joel Siegfried, *SpaceX Dragon Capsule Completes First Successful Space Station Resupply Mission*, EXAMINER.COM (Oct. 29, 2012), <http://www.examiner.com/article/spacex-dragon-capsule-completes-first-successful-space-station-resupply-mission>.

⁴¹ *Id.*; *Dawn Mission: Technology*, NASA JET PROPULSION LABORATORY, <http://dawn.jpl.nasa.gov/technology/> (last visited Mar. 7, 2013) (explaining the technology behind the Dawn satellite that recently was able to collect data from the asteroid Vesta and has now moved on to Ceres); Alex Muller, *Experimental Plasma Jet Thrusters Could Make Space Travel Cheaper*, PLANETECH (Nov. 1, 2012, 8:44 PM), <http://www.planettechnews.com/science/item2304> (explaining that recently developed pulsed-plasma jet thrusters would likely decrease the costs of space travel).

⁴² See M. J. Sonter, *The Technical and Economic Feasibility of Mining the Near-Earth Asteroids*, 41 ACTA ASTRONAUTICA 637, 644–45 (1997) (discussing “a standard ap-

promise of financial returns will drive the private sector toward making asteroid mining a reality. However, the initial cost of reaching the asteroids, developing the tools to conduct the mining, and transporting the resources back to Earth is still very large.⁴³ Not only will the initial investment be high, but there will also be substantial risks. Mining on Earth has been described as highly risky: “[R]eceiving the right to develop minerals on any given block of land is akin to buying a lottery ticket; that is, the payoff is randomly awarded.”⁴⁴ Further, “[s]uch a lottery ticket obviously would be worth substantially less than one which provided the winner with a secure transfer of the winnings to a bank account.”⁴⁵ Hence, to incentivize the private companies and make their claims economically viable, some certainty in their rights to the minerals should be granted.⁴⁶ Otherwise, the large investment will not be worthwhile.

It is in society’s best interest to make the private sector’s investments in these ventures worthwhile because the benefits will extend far beyond simply allowing private companies to realize large profits.⁴⁷ These benefits include not only access to large quantities of valuable natural resources, but also the additional

proach for carrying out Technical and Economic Feasibility Studies on proposals for asteroid resource recovery projects”).

⁴³ See Kelly M. Zullo, Note, *The Need to Clarify the Status of Property Rights in International Space Law*, 90 GEO. L.J. 2413, 2432–33 (2002) (“Private investors and commercial enterprises assume expenses and risks when undertaking business ventures. Such risks are not worth assuming unless the investor has a reasonable chance to recover all costs, including those incurred during research and development, as well as to make a profit.”). This is analogous to situations with other common carriers, such as railroads and utility companies, where the investment needed at the outset of the venture would never be made without some certainty of a monopoly in the market or property right in the fruits of the production; entry into the market must be worthwhile. R. Preston McAfee et al., *When Are Sunk Costs Barriers to Entry? Entry Barriers in Economic and Antitrust Analysis*, 94 AM. ECON. REV. 461, 464 (2004), available at <http://authors.library.caltech.edu/11284/1/MCAaer04.pdf>.

⁴⁴ See Morriss et al., *supra* note 20, at 754 (“The combination of the political risk and capital intensity mean[s] that a mining lottery ticket holder must consider the payoff if she wins as requiring that the winnings be left in an unlocked room for ten years before she spends any of it, with the room’s address and amount of money in the room published daily in the newspaper.”).

⁴⁵ *Id.* at 754–55.

⁴⁶ It is a foundational principle of property law that “[p]eople are much more likely to plan carefully and work hard when they know that the fruits of their labors will be secure to them in the form of property rights.” Carol M. Rose, *A Dozen Propositions on Private Property, Public Rights, and the New Takings Legislation*, 53 WASH. & LEE L. REV. 265, 268 (1996).

⁴⁷ Zullo, *supra* note 43, at 2433.

technological developments necessary to make the mining happen.⁴⁸ If we do not incentivize the private sector to mine asteroids, we will not reap the benefits.⁴⁹ This is because the private sector has the capital to take on space mining ventures while the public sector does not.⁵⁰ This provides even more reason to foster the private sector's ability to do so.

III. THE PRESENT STATUS OF INCENTIVIZING ASTEROID MINING

While there are some government and nongovernment incentives to encourage companies to advance their commercial space ventures, the primary present incentive to mine asteroids lies in the financial incentive to extract their valuable resources. However, no law provides any certainty that a private company will be able to obtain any property right to those valuable resources once the company extracts them. This section begins by explaining what asteroids are and why we should incentivize mining them. Next, it briefly addresses the few existing government and nongovernment incentives to mine asteroids. Finally, this section provides a short review of current agency involvement and discusses which other existing authorities would have to become involved before a necessary regulatory scheme is implemented.

A. WHY ASTEROIDS?

Near-Earth asteroids, the "asteroids whose orbits approach and/or cross the Earth's orbit,"⁵¹ are primary targets for mining due to their proximity and dense quantities of resources.⁵² Ac-

⁴⁸ *Id.* at 2433, 2435–36.

⁴⁹ *See id.* at 2433 ("[W]hile the private enterprise receives the possible financial benefit from the risky undertaking, people throughout the world stand to benefit because space resources will conserve the Earth's scarce natural resources, further scientific discovery, and boost the world economy.").

⁵⁰ Planetary Resources, Inc. is a billionaire-backed company that "is already 'a positive cash-flow company'" with a solid roadmap to advance from its present start-up stage to the asteroid-mining stage. Alex Knapp, *How Billionaire Asteroid Miners Make Money—Without Mining Asteroids*, FORBES (Apr. 27, 2012, 12:56 PM), <http://www.forbes.com/sites/alexknapp/2012/04/27/how-billionaire-asteroid-miners-make-money-without-mining-asteroids/>.

⁵¹ *See Solar System Dynamics: Asteroids*, NASA JET PROPULSION LABORATORY, <http://ssd.jpl.nasa.gov/?asteroids> (last visited Mar. 7, 2013) ("Asteroids are small rocky bodies primarily in orbit between Jupiter and Mars (i.e. main-belt). Those observed range in diameter from 948 [kilometers] (1 Ceres) to a few meters.").

⁵² Sonter, *supra* note 42, at 637–38.

cording to NASA, the majority of target asteroids are in a belt between Jupiter and Mars.⁵³ About 10% of near-Earth asteroids “are more accessible than the Moon in terms of required mission velocity for outbound and return trips,” and at least half of those asteroids would likely support mining.⁵⁴

Advancements in asteroid geology, “drawing on spectroscopic and dynamical studies of asteroids and comets,” along with meteorite studies, support the estimate that as many as 50% of near-Earth asteroids may bear volatiles in addition to various metals.⁵⁵ Those volatiles include water, oxygen, and carbon compounds, which would be useful in large-scale space activity both for supporting life and producing rocket fuels.⁵⁶ Also, asteroids are known to “contain vast supplies of very high grade metal ore” that consist of a variety of metals, including cobalt, platinum, gallium, germanium, and gold.⁵⁷

B. MOTIVATIONS AND CONCERNS REGARDING ASTEROID MINING

There are three main motivations that support mining asteroids: (1) the financial motivation to obtain large quantities of natural resources; (2) the explorative motivation to support the further exploration of outer space; and (3) the technological development motivation to develop tools and gain knowledge that will significantly impact industries beyond just the mining and space industries. These motivations provide considerable impetus for the government to establish a property right to incentivize asteroid mining. However, it is also necessary to consider the various concerns regarding mining asteroids, such as concerns about environmental impacts, which may diminish the desire to incentivize mining. This section briefly addresses these primary motivations and some of the main concerns in order to

⁵³ *Solar System Dynamics: Asteroids*, *supra* note 51.

⁵⁴ Sonter, *supra* note 42, at 640.

⁵⁵ *Id.* at 639. Spectroscopy is the “study of the absorption and emission of light and other radiation by matter, as related to the dependence of these processes on the wavelength of the radiation.” *Spectroscopy*, BRITANNICA ONLINE ENCYCLOPEDIA, <http://www.britannica.com/EBchecked/topic/558901/spectroscopy> (last visited Mar. 7, 2013).

⁵⁶ JOHN S. LEWIS, MINING THE SKY: UNTOLD RICHES FROM THE ASTEROIDS, COMETS, AND PLANETS 102–03 (1997).

⁵⁷ ROBERT ZUBRIN, ENTERING SPACE: CREATING A SPACEFARING CIVILIZATION 146 (1999) (explaining not only that there are vast quantities of these metals in high concentrations, but also that the low-gravity environment will make it relatively easy to export these metals to Earth).

highlight some of the competing interests that might come into conflict in asteroid mining ventures.

1. *Financial Motivation*

The financial motivation to mine space is much like the motivation that existed to mine the Western Frontier in the 1800s.⁵⁸ Modern industry relies on natural resources to perpetuate and grow.⁵⁹ Discovery of resources, such as oil and natural gas, created wealth not only for those who extracted the resources but also for the many industries who could use the resources.⁶⁰ As mentioned above, scientists speculate that key elements needed for modern industry could be exhausted here on Earth within the next fifty to sixty years.⁶¹ Many of these resources, such as platinum, are available on asteroids.⁶²

Asteroids also contain other resources that are nonexistent or practically nonexistent on Earth, such as helium-3.⁶³ "Helium-3 would provide a low-cost, efficient energy source while preserv-

⁵⁸ As Zubrin explains:

[O]n Earth, developing new frontiers for profit has occurred only after such regions have been explored and pioneered at considerable risk and costs by individuals possessing rather different motives.

Government space initiatives over the past forty years have tamed near-Earth space to the point where it is now a potential arena for private enterprise.

Id. at 75. The ability to access valuable minerals and profit from their extraction was also the motivation that drove miners to go into the Western Frontier. JOHN D. LESHY, *THE MINING LAW: A STUDY IN PERPETUAL MOTION* 11–13 (1987).

⁵⁹ The coal, gas, and oil industries are some of the few that are based on natural resource extraction. Scientists also believe that helium-3 found on the Moon and asteroids could provide enough energy on Earth for decades or centuries. Yukihiro Tomita et al., *Use of Polarized Helium-3 for the Energy Production*, in 402 *NUCLEAR INSTRUMENTS & METHODS PHYSICS RES. SEC. A* 421, 422, 424 (M. Tanaka ed., 1998).

⁶⁰ This is especially true of the use of natural resources for energy. In 1957, "coal, oil, and natural gas supp[lied] 93[%] of the world's energy," while in 1850 "fossil fuels supplied 5[%] of the world's energy, and men and animals 94[%]." This harnessing of energy was what made possible a standard of living far higher than that of the mid-nineteenth century." DANIEL YERGIN, *THE QUEST: ENERGY, SECURITY, AND THE REMAKING OF THE MODERN WORLD* 3 (2011).

⁶¹ See Cohen, *supra* note 11, at 34.

⁶² Joe Dysart, *Sky's the Limit: Space Law Is Taking Off*, A.B.A. J., Feb. 2013, at 19, 20.

⁶³ See Zullo, *supra* note 43, at 2433 ("Scientists postulate that [helium-3] can be used for nuclear fusion with essentially no radioactive waste or pollutant by-products. However, the Earth contains practically no [helium-3]; most of the [helium-3] that is on Earth was generated as a by-product of nuclear weapons production.").

ing the Earth's scarce natural resources."⁶⁴ In addition to helium-3, space solar power is proposed as another source of energy, promising "an endless supply of nonpolluting energy."⁶⁵ Mining and harnessing these alternative sources of energy and useful natural resources could provide a mining company with astronomical profits.⁶⁶ Additionally, other industries on Earth would reap considerable benefits from related discoveries.⁶⁷

2. *Exploration Motivation*

Throughout history, man has been fascinated with space. "[L]ong before the invention of writing or the construction of observing instruments, the sky was a cultural resource among peoples throughout the world."⁶⁸

Humanity's interest in the heavens has been universal and enduring. Humans are driven to explore the unknown, discover new worlds, push the boundaries of our scientific and technical limits, and then push further. The intangible desire to explore and challenge the boundaries of what we know and where we have been has provided benefits to our society for centuries.⁶⁹

The desire to explore space continues to be a strong motivation behind initiatives for further exploratory and commercial devel-

⁶⁴ *Id.* at 2434.

⁶⁵ *Id.*

⁶⁶ Mark Sonter, *Asteroid Mining: Key to the Space Economy*, SPACE.COM (Feb. 9, 2006, 6:51 AM), <http://www.space.com/2032-asteroid-mining-key-space-economy.html> (estimating that, once costs are reduced, some asteroids could be worth \$500,000 per ton, making them a very attractive source of materials).

⁶⁷ For example, NASA produces a brochure listing "spinoff" technological innovations from its programs. *NASA Spinoff*, NASA, <http://spinoff.nasa.gov> (last updated Aug. 11, 2011). The 2011 edition mentions a variety of spinoff technologies in the fields of health and medicine, transportation, public safety, consumer goods, energy and environment, information technology, and industrial productivity. NASA, *SPINOFF: NASA TECHNOLOGIES BENEFIT SOCIETY 2-3* (2011), *available at* <http://spinoff.nasa.gov/Spinoff2011/pdf/Spinoff2011.pdf>.

⁶⁸ Clive Ruggles & Michael Hoskin, *Astronomy Before History*, in *THE CAMBRIDGE CONCISE HISTORY OF ASTRONOMY 1* (Michael Hoskin ed., Cambridge Univ. Press 1999) (describing the involvement of astronomy in early cultures and providing examples, such as "[s]eafarers [who] navigated by the stars; agricultural communities [that] used the stars to help determine when to plant their crops; [and] ideological systems [that] linked the celestial bodies to objects").

⁶⁹ *Beyond Earth: Why We Explore*, NASA, http://www.nasa.gov/exploration/whyweexplore/why_we_explore_main.html (last updated Oct. 2, 2012). "Curiosity and exploration are vital to the human spirit and accepting the challenge of going deeper into space will invite the citizens of the world today and the generations of tomorrow to join NASA on this exciting journey." *Id.*

opment of space.⁷⁰ However, “[g]overnments [and private companies] do not spend these vast sums just for science, or merely to explore. They need another purpose, and it must make real political [and economic] sense.”⁷¹

3. *Technological Development Motivation*

The technological developments resulting from researching new technology for space exploration are extensive.⁷² NASA’s Technology Transfer and Commercialization Office has listed an abundance of developments as available for licensing by the private sector.⁷³ Those developments cover a wide variety of industries, including aerospace, biotech, green environmental technologies, communications, consumer products, electrical, manufacturing, material, optics, sensors and robotics, and software.⁷⁴ Also, the unique environment of space has allowed for advanced research in physical and biological sciences.⁷⁵ Finally, “[t]he technology needed to avert comet or asteroid impact is similar to that needed to recover the essentially unlimited resources contained in these bodies.”⁷⁶ We want to promote technological developments because they lead to life-improving and, in some instances, life-saving inventions.⁷⁷ However, as with the other motivations discussed above, there are concerns that arise with a new and uncertain venture.

⁷⁰ “This zest to explore and exploit, however thoughtless its agents may have been, has clear survival value. It is not restricted to any one nation or ethnic group. It is an endowment that all members of the human species hold in common.” CARL SAGAN, *PALE BLUE DOT: A VISION OF THE HUMAN FUTURE IN SPACE* xiv (1994).

⁷¹ Carl Sagan, *The Gift of Apollo*, *PARADE MAG.*, July 16, 1989, at 6.

⁷² Mike Wall, *Space Tech in Everyday Life: NASA Brings Inventions Down to Earth*, *SPACE.COM* (Mar. 31, 2011, 6:18 PM), <http://www.space.com/11272-nasa-space-technology-spinoffs.html> (last visited Mar. 7, 2013) (explaining that in developing technology to explore and better understand space, NASA’s technological developments have led to innovations not only in airplanes and weather forecasting but in many everyday things, such as “nutritious infant formula and sunglasses that block harmful ultraviolet light”).

⁷³ *Technology Transfer and Commercialization Office*, NASA, <http://www.nasa.gov/centers/johnson/techtransfer/technology/index.html> (last updated Oct. 3, 2011).

⁷⁴ *Id.*

⁷⁵ CYNTHIA A. EVANS ET AL., *INTERNATIONAL SPACE STATION SCIENCE RESEARCH ACCOMPLISHMENTS DURING THE ASSEMBLY YEARS: AN ANALYSIS OF RESULTS FROM 2000–2008 6–11* (2009), available at http://www.nasa.gov/pdf/389388main_ISS%20Science%20Report_20090030907.pdf.

⁷⁶ Sonter, *The Technical and Economic Feasibility*, *supra* note 42, at 637.

⁷⁷ See Wall, *supra* note 72.

4. Concerns

As noted above, while there are strong financial, exploratory, and technological motivations that incentivize asteroid mining, it is important to have some understanding of the concerns that might counterbalance these motivations. As with all new endeavors, myriad concerns have been raised regarding the disadvantages and risks of mining asteroids.⁷⁸ Safety concerns are abundant, ranging from the safety of mine workers and operators working on the asteroid⁷⁹ to even the safety of humanity itself. The latter concern is based on the theory that an asteroid could be pushed out of orbit and into an Earth-destroying trajectory.⁸⁰ There are also “‘cosmocentric’ environmentalism or ‘astroenvironmentalism’” movements that argue against the disruption of the “pristine” environment of space.⁸¹ Additionally,

⁷⁸ These include not only concerns about competing interests, but also accommodation doctrine issues. The accommodation doctrine presents issues of the division of ownership in one piece of land: “[T]he surface of the land may be separated from the different *strata* underneath it, and there may be as many different owners as there are *strata*.” *Chartiers Block Coal Co. v. Mellon*, 152 Pa. 286, 295 (1893). The owner of minerals will generally have the right to trespass upon the surface, which may be owned by someone else, in order to obtain his underlying estate. *Id.* In an international context where sovereignty over celestial bodies is a concern, this could create further conflict. *See id.*

⁷⁹ RASBAND ET AL., *supra* note 13, at 1031 (recognizing that mining is one of the most dangerous professions on Earth; “[t]he Federal Mine Safety and Health Act, 30 U.S.C. § 801–962, provides comprehensive protection for mine workers under the auspices of the Mine Safety and Health Administration”). The NASA Human Exploration and Operations Mission Directorate was created in 2011 through a merger of the Exploration Systems and Space Operations mission directorates. CHARLES F. BOLDEN, JR., NASA FY 2013 BUDGET REQUEST EXECUTIVE SUMMARY: MESSAGE FROM THE ADMINISTRATOR 9 (2013), *available at* http://www.nasa.gov/pdf/632669main_NASA_FY13_Budget_Agency-Summary-508.pdf. This organization is “uniquely equipped to implement NASA’s human spaceflight goals to achieve a safe, reliable, and affordable program that will sustain human space exploration efforts over the long term.” *Id.*

⁸⁰ Carl Sagan and Steven J. Ostro raise the concern that altering the trajectories of asteroids in nearby interplanetary space could cause a catastrophic collision with Earth, which should support the requirement to institute stringent controls on the misuse of orbit-engineering technology. STEVEN J. OSTRO & CARL SAGAN, COSMIC COLLISIONS AND THE LONGEVITY OF NON-SPACEFARING GALACTIC CIVILIZATIONS 2, 5 (1998), *available at* <http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/19498/1/98-0908.pdf>.

⁸¹ *See* J. H. Huebert & Walter Block, *Space Environmentalism, Property Rights, and the Law*, 37 U. MEM. L. REV. 281, 282–86 (2007) (recognizing with cynicism the application of the extreme ecocentric environmentalism perspectives on preservation of the original pristine state of space and proposing “a regime of full private property rights and strict liability” lying at the opposite end of the spectrum from more extreme environmentalism). The ecocentric perspective here on

asteroid mining could potentially lead to the violation of international treaties, such as the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty of 1967).⁸²

Some of these concerns regarding the disadvantages and risks of asteroid mining will inevitably be second-order concerns, meaning they may become relevant only if, as a first-order solution, a property regime that incentivizes asteroid mining is created. Thus, in order to address the concerns, the law must first develop to the point where it encourages investors to mine the asteroids. Once the law reaches that point, there will then be a need to synthesize the property regime with additional international governance concerns. However, that is beyond the scope of this article, which is concerned with the first-order issue of how we incentivize the prospecting and mining of asteroids in the first place.

C. CURRENT PROGRAMS IN PLACE TO INCENTIVIZE

The previously discussed concerns are not likely to be strong enough to defeat the motivating factors that support asteroid mining. However, the financial, exploratory, and technological development-based motivations behind the mining of asteroids will not be enough, by themselves, to assure companies seeking to mine asteroids that their investments will be worthwhile. Again, it would be difficult to incentivize investment without the

Earth "is not limited to concern for animals or even plants, but extends to the entire Earth, dirt and rocks included. Everything on Earth, except for humans, is seen as possessing 'intrinsic value' . . . that is destroyed or threatened by any human tampering at all." *Id.* at 284–85.

⁸² Several scholars interpret the Outer Space Treaty of 1967 to extend only to state sovereignty over territories in space and not to include private appropriation. See Virgiliu Pop, *Appropriation in Outer Space: The Relationship Between Land Ownership and Sovereignty on the Celestial Bodies*, 16 SPACE POL'Y 275, 275 (2000) (discussing the different interpretations of the Outer Space Treaty from the perspective that private appropriation and national sovereignty are entirely different branches of the law); Rand Simberg, *Homesteading the Final Frontier: A Practical Proposal for Securing Property Rights in Space*, COMPETITIVE ENTERPRISE INST., Apr. 2012, at 1, available at <http://cei.org/issue-analysis/homesteading-final-frontier> (acknowledging that while "[m]any believe that the 1967 Outer Space Treaty implicitly prohibits private property in outer space, . . . under another conceivable interpretation, it only prohibits declarations of national sovereignty"); but see Listner, *supra* note 9, at 80 ("The Outer Space Treaty does not delineate between the activities of government agencies and non-governmental agencies; the controlling state is presumed equally responsible for the activities of both.").

requisite property rights. Presently, there are very few government and nongovernment projects that incentivize exploring and developing space.

The primary government incentives to encourage exploring and commercializing come from NASA and other agency partnerships with private organizations; these incentives consist of assistance in developing the technology necessary for various missions.⁸³ While these partnerships might support private commercialization by providing the private sector with the technology it needs to accomplish such ventures, they provide no assurance that a large investment to extract natural resources will be worthwhile. There is presently no national or international government-created property right arrangement to support asteroid mining by private firms.⁸⁴

In addition to the limited government incentives, several private incentive programs exist to encourage private commercialization of outer space. The X PRIZE Foundation is one of the leaders in providing nongovernment incentives to encourage space exploration projects.⁸⁵ The X PRIZE Foundation is a “nonprofit organization whose mission is to bring about radical breakthroughs for the benefit of humanity, thereby inspiring the formation of new industries and the revitalization of markets that are currently stuck due to existing failures or a commonly held belief that a solution is not possible.”⁸⁶ The X PRIZE Foundation offers several prizes to encourage space exploration.⁸⁷

⁸³ One of the main purposes of NASA is to “seek and encourage, to the maximum extent possible, the fullest commercial use of space.” 51 U.S.C. § 20102(c) (2012). Thus, NASA appears to try and create collaboration synergies with the private sector wherever possible to further this purpose. See NASA, 2011 NASA STRATEGIC PLAN 6, 9 (2011) [hereinafter 2011 NASA STRATEGIC PLAN], available at http://www.nasa.gov/pdf/516579main_NASA2011StrategicPlan.pdf. Also, the Department of Defense “is expanding partnerships with spacefaring companies and nations to maintain the strategic advantage it gains in space.” Cheryl Pellerin, *DOD Space Program Broadens Industry, Foreign Partnerships*, AM. FORCES PRESS SERVICE (July 19, 2011), <http://www.defense.gov/news/newsarticle.aspx?id=64730>.

⁸⁴ One reason for the absence of a recognized system of property rights could be the uncertainty of whether a right could exist under international treaties, which, again, is beyond the scope of this article. See *supra* note 19.

⁸⁵ *Who We Are*, X PRIZE FOUND., <http://www.xprize.org/about/who-we-are> (last visited Mar. 7, 2013).

⁸⁶ *Id.*

⁸⁷ *X PRIZE Foundation Space Initiatives*, X PRIZE FOUND., <http://space.xprize.org/> (last visited Mar. 7, 2013) (listing the Ansari X PRIZE, X PRIZE Cup, Google Lunar X PRIZE, and Northrop Grumman Lunar Lander X CHALLENGE

Past X PRIZE awards include the Ansari X PRIZE,⁸⁸ the X PRIZE Cup,⁸⁹ and the Northrop Grumman Lunar Lander X PRIZE.⁹⁰ One of the largest X PRIZES currently being offered is the Google Lunar X PRIZE, which will award \$30 million

to the first privately funded teams to safely land a robot on the surface of the Moon, have that robot travel 500 meters over the lunar surface, and send video, images[,] and data back to the Earth. Teams must be at least 90% privately funded, though commercially reasonable sales to government customers are allowed without limit.⁹¹

Other organizations have proposed providing prizes and incentives to further space exploration; however, many of those proposals have not come to fruition.⁹²

In sum, there are currently two non-regulatory ways that the private sector and public sector provide additional incentives to encourage private companies to commercially develop space: (1) the few large private prize awards; and (2) the advanced technology support from the government. While there is some administrative agency involvement in the government offering technological support,⁹³ other agencies would also be involved in the regulation of commercial space mining endeavors. These other agencies will be necessary because of the complexity of commercial space mining.

D. PRESENT AGENCY INVOLVEMENT

It is important to identify some of the many agencies that would be involved in implementing an asteroid mining law and recognize that they would create regulatory hurdles to this ef-

as some of the past and present prizes relating to space exploration through the X PRIZE Foundation).

⁸⁸ *Ansari X PRIZE*, X PRIZE FOUND., <http://space.xprize.org/ansari-x-prize> (last visited Mar. 7, 2013).

⁸⁹ *X PRIZE Cup*, X PRIZE FOUND., <http://space.xprize.org/x-prize-cup> (last visited Mar. 7, 2013).

⁹⁰ *Northrop Grumman Lunar Lander X PRIZE*, X PRIZE FOUND., <http://space.xprize.org/lunar-lander-challenge> (last visited Mar. 7, 2013).

⁹¹ *Prize Details*, GOOGLE LUNAR X PRIZE, <http://www.googlelunarxprize.org/prize-details> (last visited Mar. 7, 2013).

⁹² For example, the Space Settlement Institute has recently proposed the Space Settlement Prize Act, which "would create, at no cost to taxpayers, a multi-billion dollar incentive for private companies to finance and build permanent settlements on the Moon and/or Mars." *The Space Settlement Prize Act*, SPACE SETTLEMENT INST., <http://www.space-settlement-institute.org/space-settlement-prize-act.html> (last visited Mar. 7, 2013).

⁹³ See *supra* note 83 and accompanying text.

fort. In the United States, NASA appears best suited to be the lead agency involved in regulating and helping implement an asteroid mining law.⁹⁴ However, there are many other agencies that would likely have jurisdictional claims to regulatory authority over these matters.

NASA is responsible for all aeronautical and space activities for the welfare and security of the United States.⁹⁵ One of the main purposes of NASA is to “seek and encourage, to the maximum extent possible, the fullest commercial use of space.”⁹⁶ In carrying out this purpose, NASA set goals within its 2011 Strategic Plan to transfer its technology⁹⁷ and “engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.”⁹⁸ NASA has already partnered with SpaceX and Orbital Space Corporation, which are private companies providing various space-transportation services to NASA.⁹⁹

While NASA is the primary agency currently involved in space exploration and may take the lead in developing any comprehensive asteroid mining regulations, several other existing agencies may find themselves to have jurisdictions that cross into the regulation of asteroid mining.¹⁰⁰ Those agencies include the Federal Aviation Administration,¹⁰¹ the Environmental Protec-

⁹⁴ See 51 U.S.C. § 20102 (2012).

⁹⁵ *Id.* § 20102(b).

⁹⁶ *Id.* § 20102(c).

⁹⁷ NASA has long been a technological leader and will continue to be so for the venture to commercialize space. It is currently “developing a robotic explorer at Kennedy Space Center in Florida to track down water on the [M]oon, Mars[,] or on an asteroid.” *RESOLVE Rover Tests in Situ Resource Utilization in Hawaii*, SPACE SAFETY MAG. (July 17, 2012, 5:38 AM), <http://www.spacesafetymagazine.com/2012/07/17/resolve-rover-tests-situ-resource-utilization-hawaii/>.

⁹⁸ 2011 NASA STRATEGIC PLAN, *supra* note 83, at 5 (“Strategic Goal 3: Create the innovative new space technologies for our exploration, science, and economic future.”).

⁹⁹ *Id.* at 9.

¹⁰⁰ See Henry R. Hertzfeld & Frans G. von der Dunk, *Bringing Space Law into the Commercial World: Property Rights Without Sovereignty*, 6 CHI. J. INT’L L. 81, 83 n.6 (2005) (“In the United States, the applicability of various Environmental Protection Acts to federal government and private activities in outer space remains an open question.”).

¹⁰¹ The Federal Aviation Administration (FAA) already plays a role in space exploration by issuing commercial space transportation licenses or experimental permits after determining that a launch or reentry proposal, a proposal to test equipment, or other proposal involving launch or reentry from earth to space “will not jeopardize public health and safety, property, U.S. national security or foreign policy interests, or international obligations of the United States.” *Licenses*

tion Agency,¹⁰² the Department of Defense,¹⁰³ and the Department of State.¹⁰⁴ With all of this agency involvement, there would likely need to be a subagency created under NASA to regulate private sector asteroid mining.¹⁰⁵

IV. THE HISTORY OF INCENTIVIZING NATURAL RESOURCE MINING IN THE UNITED STATES AND THE GENERAL MINING LAW OF 1872

A brief overview of the history of incentivizing natural resource mining in the United States, leading up to and including the Mining Law, is necessary to understand how the different avenues of property rights have or have not worked as incentives. Accordingly, this section provides a brief overview of the history of incentivizing natural resource mining and a summary of the Mining Law.

ℰ Permits: Commercial Space Transportation, FAA, http://www.faa.gov/licenses_certificates/commercial_space_transportation/ (last modified Sept. 3, 2010). There will be a continuing need for the FAA to regulate these commercial endeavors—even more so as the utilization of space launches and reentries increases.

¹⁰² The Environmental Protection Agency (EPA) reaches far and wide in the United States. Its responsibilities lie in the area of pollution control. The EPA “has general authority to review[] all draft and final environmental impact statements prepared by all federal agencies.” RASBAND ET AL., *supra* note 13, at 217. NASA already has several programs aimed at the EPA accomplishing its environmental goals. It is also likely that activities such as the exit and reentry of spacecraft to and from Earth will fall under the jurisdiction of the EPA and may encounter significant obstacles if they are found to be too polluting. *See Catalog of Environmental Programs 2012: National Aeronautics & Space Administration*, EPA, <http://www.epa.gov/oig/catalog/agencies/NASA.html> (last visited Mar. 7, 2013); *see generally* April Greene Apking, *The Rush to Develop Space: The Role of Spacefaring Nations in Forging Environmental Standards for the Use of Celestial Bodies for Governmental and Private Interests*, 16 COLO. J. INT’L ENVTL. L. & POL’Y 429 (2005); Jonathan Remy Nash, *The Curious Legal Landscape of the Extraterritoriality of U.S. Environmental Laws*, 50 VA. J. INT’L L. 997 (2010).

¹⁰³ The Department of Defense (DOD) will likely seek to monitor space activity to ensure that ventures do not pose a threat to national security. *See About the Department of Defense (DOD)*, DOD, <http://www.defense.gov/about/> (last visited Mar. 7, 2013). As mentioned above, the DOD “is expanding partnerships with spacefaring companies and nations to maintain the strategic advantage it gains in space.” Pellerin, *supra* note 83.

¹⁰⁴ The Department of State will also be involved in a commercial space mission. This department implements the President’s foreign policies and represents the United States in its diplomatic relations. *See* Ronald L. Spencer, Jr., *State Supervision of Space Activity*, 63 A.F. L. REV. 75, 123 (2009).

¹⁰⁵ *See infra* Part V.C.

A. PROPERTY RIGHTS AND MINING REGULATION LEADING UP TO
THE GENERAL MINING LAW OF 1872

The premise, dating back to Roman times, that “[m]ineral exploration and development should have preference over all uses of the land because they are the highest economic use of the land” persists as a theme underlying the property law and regulatory principles that came out of early America and that still resonate in much of the law today.¹⁰⁶ Consistent with this premise, Thomas Jefferson wrote in his *Notes on the State of Virginia* in 1785 that “[c]ultivators of the Earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous, and they are tied to their country, and wedded to its liberty and interests, by the most lasting bonds.”¹⁰⁷ The Jeffersonian perspective of “the public lands as a nursery of virtuous citizens” has held significant influence on public land policy.¹⁰⁸ Embedded in this perspective were the “Jeffersonian concern about political equality and the original states’ concern of sharing in the benefits of the West’s resources”; both concerns found themselves in tension with the land rights and sovereignty afforded new states as the United States continued to expand.¹⁰⁹ This tension resurfaced throughout history as rules and laws were developed to incentivize the development of the Western Frontier.

“During its first [eighty-three] years, the United States did not have an explicit and coherent mineral policy for the public lands.”¹¹⁰ The “first in time, first in right” principle was highly influential and essentially governed early property acquisition.¹¹¹ The “discovery doctrine” came out of the “first in time,

¹⁰⁶ RASBAND ET AL., *supra* note 13, at 1079 (quoting DAVID SHERIDAN, COUNCIL ON ENVTL. QUALITY, EXEC. OFFICE OF THE PRESIDENT, *HARD ROCK MINING ON THE PUBLIC LAND* (1977)).

¹⁰⁷ *Id.* at 83 (quoting THOMAS JEFFERSON, *NOTES ON THE STATE OF VIRGINIA* 157 (1785)).

¹⁰⁸ *Id.* (“This Jeffersonian vision of the public lands as a nursery of virtuous citizens was long to hold sway in public land policy and even today exerts significant influence.”).

¹⁰⁹ *Id.* at 96.

¹¹⁰ *Id.* at 1078 (quoting SHERIDAN, *supra* note 106).

¹¹¹ See JESSE DUKEMINIER ET AL., *PROPERTY* 12 (7th ed. 2010). The principle of “first in time, first in right” is another principle dating back to Roman law. *Id.* “The notion that being there first somehow justifies ownership rights is a venerable and persistent one,” underlying many forms of property rights throughout history. *Id.* (quoting LAWRENCE C. BECKER, *PROPERTY RIGHTS: PHILOSOPHICAL FOUNDATIONS* 24 (1997)).

first in right" principle, establishing that the first to discover land is the rightful sovereign.¹¹² This doctrine was used to settle acquisition-right disputes among the colonies.¹¹³ Other rules, such as the rule of capture, also stemmed from the "first in time, first in right" principle.¹¹⁴ The rule of capture came about "[i]n the early development of oil and gas in the United States" and "allowed the owner of an oil and gas property to drill a well and extract as much oil and gas as possible, even where the drill operator was draining the resources underneath neighboring properties."¹¹⁵ Basically, the owner was allowed to keep whatever he captured first.

The inadequacy of these rules eventually became apparent as developers raced to claim their oil, for example, and "anarchy" ensued.¹¹⁶ Accordingly, government regulation of property rights in the acquisition of land and natural resources began.¹¹⁷ Some of the early regulations allowed the government to evict trespassers from public lands and grant short-term leases to public mineral lands; these regulations led up to the Mining Law.¹¹⁸ The formulation of these regulations, including the Mining Law, took into account both acquisition rules and common-law property rights for the disposition of property.¹¹⁹

Some examples of disposition rights are licenses, profits à prendre, auctioning systems, and profits accompanied by royalties. A license creates "a personal privilege in the licensee to remove minerals in accordance with the terms of the license."¹²⁰ A profit à prendre creates a "nonpossessory, usufructuary, commercial right to remove minerals and is 'presumptively assignable, inheritable, and exclusive.'"¹²¹ Auctioning of ownership

¹¹² See *Johnson v. M'Intosh*, 21 U.S. 543, 573-74 (1823).

¹¹³ See *id.* at 573 ("[A]s they were all in pursuit of nearly the same object, it was necessary, in order to avoid conflicting settlements, and consequent war with each other, to establish a principle, which all should acknowledge as the law by which the right of acquisition, which they all asserted, should be regulated as between themselves.").

¹¹⁴ *DUKEMINIER ET AL.*, *supra* note 111, at 14, 38.

¹¹⁵ *RASBAND ET AL.*, *supra* note 13, at 1036.

¹¹⁶ *Id.*

¹¹⁷ *Id.*

¹¹⁸ John Umbeck, *The California Gold Rush: A Study of Emerging Property Rights*, 14 *EXPLORATIONS IN ECON. HIST.* 197, 203 (1977).

¹¹⁹ *Morriss et al.*, *supra* note 20, at 761-62.

¹²⁰ *RASBAND ET AL.*, *supra* note 13, at 1043 ("A license is revocable, and generally cannot be assigned or inherited.").

¹²¹ *Id.* (quoting 3 *ROCKY MOUNTAIN MINERAL FOUND.*, *AMERICAN LAW OF MINING* § 82.03[3]).

rights essentially allows the rights to go to the highest bidder.¹²² A profit accompanied by a royalty interest exists where a non-expense-bearing commercial interest is held in the gross production resulting from a venture.¹²³ Other forms of property rights, such as pooling agreements, emerged around this time as well.¹²⁴

Some of these common-law rights served as foundations for developing government land policies, while others were rejected. Minerals on public lands, such as iron and lead, were frequently leased while the surface rights were retained or later sold for farming.¹²⁵ However, leasing systems were discretionary and typically required significant transfer fees, thus impeding the principle of free access, which served as a strong incentive to mine.¹²⁶

The U.S. government came to realize that the administrative burden of managing public land justified disposing of it by granting it to settlers.¹²⁷ This led to the Homestead Act, which was intended to entirely dispose of plots of public lands to settlers, “end[ing] [seventy] years of debate about ‘giving’ away public land.”¹²⁸ However, complete disposal of public land was not practical in all situations due to differing levels of expertise

¹²² Ezra J. Reinstein, *Owning Outer Space*, 20 NW. J. INT’L L. & BUS. 59, 90 (1999) (discussing the advantages of implementing an auction system as part of a system for allocating property ownership rights in space). However, auction systems “often require discretionary choices by government actors of the particular resources to auction and the structure of the auction,” which can easily lead to corruption. Morriss et al., *supra* note 20, at 755, 773–77.

¹²³ RASBAND ET AL., *supra* note 13, at 1043–44. Royalty interests “exist independent of any rights to control development, or responsibility for development costs.” *Id.* at 1044.

¹²⁴ *Id.* at 1036 (“One of the earliest forms of equitable sharing of oil and gas resources was the pooling agreement whereby owners of land overlying a common oil and gas reservoir on which there was a single well site agreed to share equitably the costs and revenues from oil and gas production.”).

¹²⁵ See *id.* at 1043–44. A mineral lease is “a possessory right to develop a mineral deposit, generally for a set term of years, but the term is usually extended indefinitely during mineral production.” *Id.* at 1043. Since this is a possessory right, the lessee is able to exclude others from the leased land and “receives the right to extract minerals along with any necessary incidental rights such as access and surface use.” *Id.* In exchange, the “landowner receives compensation for the lease in the forms of bonus payments, royalties, and/or rentals, and retains ownership of the land, which will be unencumbered once the lease term expires or otherwise terminates by operation of law.” *Id.*

¹²⁶ Morriss et al., *supra* note 20, at 755.

¹²⁷ RASBAND ET AL., *supra* note 13, at 120.

¹²⁸ KENNETH J. ALLEN, *FEDERAL GRANT PRACTICE* § 2:7 (2012 ed. 2012) (“The Homestead Act of 1862 was federal assistance that ‘granted’ 160 acres . . . of

and sophistication on the part of grantees; furthermore, complete disposal was either undesirable or unnecessary to achieve targeted goals.¹²⁹ Thus, division of the “sticks” in the “bundle” was more appropriate to exploit superior expertise and maximize achievement of the targeted goals, such as the extraction of resources, especially when mining boomed in the mid-1800s due to the gold rush.¹³⁰

The predecessor laws of the Mining Law, such as the Lode Law of 1866, exemplified this division of the bundle of sticks because they did not provide for complete disposal of the land, but they still provided a few significant rights to miners. The Lode Law of 1866 essentially made it legal for miners to trespass on public lands to appropriate minerals.¹³¹ Eventually, what evolved out of the common-law property rights and these predecessor laws was the Mining Law, which provided a license to miners to go on public land and a profit à prendre to take and own minerals from that land.¹³²

B. THE GENERAL MINING LAW OF 1872

Entitled “An Act to promote the Development of the mining Resources of the United States,”¹³³ the Mining Law has had, and

public land to settlers who declared their intention to build farms and who would maintain the granted land for at least five years.”).

¹²⁹ Many argue that the Homestead Act was a true failure because it discarded land into the hands of settlers who did not have the resources or knowledge to make use of it. See RASBAND ET AL., *supra* note 13, at 122. It was viewed as “one of the most durable and destructive myths in American folklore.” *Id.* “Most of the lush American land was occupied well before 1862, and successful homesteading took place primarily in the upper Midwest. The incredible toil of the Great Basin homesteader was frequently rewarded by drought, blizzard, dust storm[,] and financial and physical ruin.” *Id.*

¹³⁰ The Mining Law and its predecessor, the Lode Law of 1866, were created out of the realization “that some order had to be brought out of the chaos of the Gold Rush” that followed “the discovery of gold in California in 1848.” Roger Flynn, *The 1872 Mining Law as an Impediment to Mineral Development on the Public Lands: A 19th Century Law Meets the Realities of Modern Mining*, 34 LAND & WATER L. REV. 301, 302 (1999).

¹³¹ RASBAND ET AL., *supra* note 13, at 1079. The Placer Act of 1870 amended the Lode Law of 1866, “and the two were consolidated in the Mining Law of 1872.” *Id.* “[L]odes are vein-like deposits, picture a miner following a spidery vein of gold running along the ceiling of a mine. A placer (pronounced ‘plass-er’) refers to unconsolidated mineral deposits” *Id.* at 1087.

¹³² See 30 U.S.C. §§ 21–54 (2012).

¹³³ General Mining Law of 1872, ch. 152, 17 Stat. 91 (1872) (codified as amended at 30 U.S.C. §§ 21–54 (2012)). The Mining Law “still allows miners to develop mineral deposits on available federal lands without charge and to obtain a patent, or fee simple title, to their claims for a nominal cost, although a morato-

continues to have, significant influence on the laws governing natural resource mining in the United States.¹³⁴ The Mining Law was enacted to encourage citizens and domestic corporations to go out and develop the minerals on public lands.¹³⁵ It “allows any citizen or domestic corporation to go on to public lands” to prospect for minerals.¹³⁶ If the prospecting reveals valuable minerals, the citizen or corporation can stake a mining claim and purchase the land from the government.¹³⁷

The Mining Law followed the California Gold Rush of 1848, which created “national hysteria that drove thousands westward [but] got down to earth when gold seekers assembled in a placer mining locality to write property rules governing their local district.”¹³⁸ The gold rush embodied the Jeffersonian desire to cultivate the land and resulted in a “western mining boom.”¹³⁹ But the “miners needed rules to define what constituted a claim and what the size of the claim should be, to require that the claim be recorded, and to define the limits of use of property.”¹⁴⁰ The miners wanted “some sense of certainty in the ground they were working.”¹⁴¹

In the Mining Law, “Congress declared that all valuable mineral deposits on the public domain were ‘free and open to exploration and purchase.’”¹⁴² Once a valuable mineral deposit is believed to be located on eligible federal land, an individual can stake a claim under the Mining Law by following a relatively simple process and paying modest fees.¹⁴³ Claim holders are given the option to make multiple claims.¹⁴⁴ These claim holders are

rium on filing new applications for patents to mining claims has been in place since 1994.” 5 WEST’S FED. ADMIN. PRAC. § 5851 (4th ed. 2002) (internal citations omitted).

¹³⁴ See Morriss et al., *supra* note 20, at 748–49 (“Despite high-level attacks on this system and a gradual narrowing of the scope of the minerals appropriable under the Mining Law and the lands available for appropriation, more than a century and a half later the basic system remains intact for hardrock minerals.”).

¹³⁵ *United States v. Bagwell*, 961 F.2d 1450, 1453 (9th Cir. 1992).

¹³⁶ RASBAND ET AL., *supra* note 13, at 1077.

¹³⁷ *Id.*

¹³⁸ GORDON MORRIS BAKKEN, *THE MINING LAW OF 1872: PAST, POLITICS, AND PROSPECTS* 16 (2008).

¹³⁹ See RASBAND ET AL., *supra* note 13, at 1079 (quoting SHERIDAN, *supra* note 106).

¹⁴⁰ BAKKEN, *supra* note 138, at 16.

¹⁴¹ *Id.*

¹⁴² *Id.* at 9.

¹⁴³ *Id.*

¹⁴⁴ Morriss et al., *supra* note 20, at 756.

never required to actually produce minerals, but if minerals are found, there is no requirement for payment of royalties beyond the minor fees to the federal government.¹⁴⁵ Where a mineral deposit is determined to be economically viable and the claimant performs at least \$500 of development work, the claimant may file a "patent application to receive fee simple title to both mineral and surface rights or just the mineral rights at the claimant's option."¹⁴⁶

Essentially, the Mining Law sought to incorporate certain types of common-law arrangements into statutes so that the government could retain some rights in the "bundle of sticks" existing in public lands. It created a license and a profit à prendre¹⁴⁷ with the government serving as the servient estate holder.¹⁴⁸ Congress could have created a leasing or auction system,¹⁴⁹ or a profit accompanied by a royalty.¹⁵⁰ But Congress chose not to emulate those portions of the common law.¹⁵¹ Instead it provided an arrangement that—unlike the other options—featured a low transfer cost and high certainty of obtaining property rights.¹⁵²

¹⁴⁵ *Id.*

¹⁴⁶ *See id.* ("[S]ince 1989 a \$250 fee per application, plus a separate \$50 per claim fee, is also required.")

¹⁴⁷ The license to go on the land and the profit à prendre comprise the non-possessory right to commercially remove the minerals from the land and retain the title in those minerals.

¹⁴⁸ Since the land is burdened by the miners' nonpossessory interests in the land, or the servitude, the government holds a servient estate. JOSEPH W. SINGER, *PROPERTY LAW* 177 (3d ed. 2002).

¹⁴⁹ *Morriss et al.*, *supra* note 20, at 755.

Once a claimant has satisfied the objectively verifiable requirements of the law, the property rights *must* issue without a significant payment. These are crucial distinctions between the Mining Law and alternatives such as leasing systems or auctions, the main alternatives proposed by the Mining Law's critics. In leasing systems, the determination of whether to provide a lease is generally discretionary, and auction systems often require discretionary choices by government actors of the particular resources to auction and the structure of the auction. Both, of course, also require significant transfer fees.

Id. (citation omitted).

¹⁵⁰ A profit accompanied by a royalty interest exists where a "non-expense[-]bearing [commercial] interest[]" is held in the gross production resulting from the venture. *RASBAND ET AL.*, *supra* note 13, at 1043–44. Royalty interests "exist independent of any rights to control development, or responsibility for development costs." *Id.* at 1044.

¹⁵¹ *Morriss et al.*, *supra* note 20, at 758.

¹⁵² *See id.* at 755.

The Mining Law provides a rather simple scheme to appropriate property rights and encourages private individuals to invest in the extraction of valuable minerals without granting complete sovereignty.¹⁵³ While proven to be sufficiently effective to still be in place today, the law is not without its flaws.

C. EVALUATING THE EFFECTIVENESS, CONSEQUENCES, AND LIMITATIONS OF THE GENERAL MINING LAW OF 1872

As mentioned above, this relatively simple property right scheme has proven to be an effective model to encourage private investment in the extraction of minerals from public lands without giving complete sovereignty in the land.¹⁵⁴ However, the law is not without shortcomings and limitations. This section highlights some of the battles and successes of the Mining Law over time, in anticipation of the reactions that similarly situated critics will have with respect to laws governing mining in space. This section is not intended to be a comprehensive examination of such claims, but instead seeks to provide a realistic recognition of the opposition's framework while recognizing the Mining Law's primary strengths.

According to one set of authors, "in the eyes of most commentators, the Mining Law is an anachronism—a massive subsidy to the mining industry that no longer serves the public interest."¹⁵⁵ The list of criticisms is extensive.¹⁵⁶ However, the main criticisms of a modern application of the Mining Law in the context of asteroid mining center on environmental concerns and revenue generation for the federal government.¹⁵⁷

¹⁵³ See 30 U.S.C. § 22 (2012).

¹⁵⁴ *Id.*

¹⁵⁵ RASBAND ET AL., *supra* note 13, at 1077.

¹⁵⁶ See Morriss et al., *supra* note 20, at 749–50 (listing criticisms of the Mining Law, including that it “allows uncontrolled mining, a menace which can strike almost anywhere, often in the midst of the most environmentally valuable and vulnerable places”; it “lets huge mining conglomerates wreak environmental havoc on public lands”; and it “plunders taxpayers and is the largest ongoing scam in American history”) (alterations, citations, and internal quotation marks omitted).

¹⁵⁷ *Id.* at 750. Additional criticisms include that the law does not impose adequate standards to ensure that claims are exercised with diligence and that it allows the option of patenting public lands that contain valuable mineral deposits. RASBAND ET AL., *supra* note 13, at 1082. Due diligence would likely be a lesser concern, considering the great initial expenditure necessary to get to the asteroid. The ability to patent public lands would probably need to be handled differently in the asteroid mining law, possibly by only allowing patenting of the mineral resource and not surface ownership.

There is no denying that the mining that has taken place under the Mining Law has impacted the environment. The Mining Law does not independently address the issue of environmental protection.¹⁵⁸ Environmental protection was hardly a focus at the time of the Mining Law's implementation, and the effects of this lack of protection have been long lasting.¹⁵⁹ Many efforts had to be made after the Mining Law had been in place almost 100 years to repair the environmental damage done; one such effort was the Surface Mining Control and Reclamation Act.¹⁶⁰ The extensiveness of this damage supports a precautionary approach to the implementation of an asteroid mining act.¹⁶¹

The fact that several strong parallels can be drawn between the status of the Western Frontier when the Mining Law was first enacted and the current untouched status of outer space also gives those with a precautionary reaction fuel for their arguments. International treaties, such as the Outer Space Treaty of 1967,¹⁶² may provide a framework for extending environmental law to space. However, there is not presently a comprehensive structure for environmental regulation in space.¹⁶³ Thus, like the Western Frontier during the enactment of early mining regulations, there are no environmental safeguards in place in space. Also, similar to when the Mining Law was first enacted, some "pristine" aspects of space still remain untouched by

¹⁵⁸ BAKKEN, *supra* note 138, at 82 ("The Mining Law of 1872 did not address the problem of tailings disposal or pollution. The common law was the only recourse for early miners. Today we see the results.").

¹⁵⁹ *Id.*

¹⁶⁰ *See id.* at 113 ("In 1977, Congress passed the Surface Mining Control and Reclamation Act (Public Law 95-87) taxing working coal mines. The purpose was to create a fund for the mitigation of surface damage to mined lands.").

¹⁶¹ The precautionary principle is a strategy that places the burden on those who wish to conduct the offending activity to prove that there is not a serious and credible threat. RASBAND ET AL., *supra* note 13, at 43.

¹⁶² *See* Apking, *supra* note 102, at 447.

The Outer Space Treaty of 1967 recognizes that activities in space should be carried out in the spirit of cooperation and 'with due regard to the corresponding interests of all other States Parties to the Treaty [If an activity or experiment] would cause potentially harmful interference with activities in the peaceful exploration and use of outer space,' a nation has the right to seek consultation regarding the activity.

Id. (citation omitted). Apking suggests that this is an "attempt[] to place a limit on environmental damage" but that it is "confined to research and exploration."

Id. (citation omitted) (internal quotation marks omitted).

¹⁶³ *Id.* at 446.

man.¹⁶⁴ But, unlike when the Mining Law was enacted, society is not as environmentally blind as the miners setting out to make a fortune in gold.¹⁶⁵ The world is more environmentally conscious today, thus making it better attuned to realize where industry is causing impactful destruction.¹⁶⁶

Whenever property rights are established, environmentalists become alarmed.¹⁶⁷ Property rights, particularly those of an extractive nature, disrupt the landscape and necessarily disturb natural resources.¹⁶⁸ When natural resources are disturbed, concerns about the irreparable damage caused to the environment inevitably arise.¹⁶⁹ While these concerns should be considered, they should not override the quest to make technological advancements. In other words, gaining valuable resources should not be hindered solely because of potential environmental impact.

Although environmental regulations should not prevent the acquisition of property rights, these regulations should not be ignored. After setting up a property rights framework, as discussed in this article, the next preliminary step would need to be the anticipatory creation of environmental regulations for mining activities. That preemptive step is beyond the scope of this

¹⁶⁴ *Id.* at 430 (“[A]long with the new potentials for space travel currently being developed come various responsibilities to the outer space environment, responsibilities that must ensure that the outer space environment is kept as pristine as possible.”).

¹⁶⁵ *Id.* at 432 (arguing that we should tread cautiously into space and that in applying our “newfound understanding of how our actions can destroy the delicate environment of this planet, we must be careful not to treat the environments of other celestial bodies . . . with the same disregard with which we have treated Earth’s ecosystem”).

¹⁶⁶ *See id.* at 431–32 (“Recently, we have begun to understand and recognize the damage we do in the name of technological advancement. In turn, our understanding has led to increased concern for the Earth’s environment. This concern is evidenced by the participation of many profit-seeking groups, even corporations, in the sponsorship of environmental groups and their efforts.”).

¹⁶⁷ MITCHELL THOMASHOW, *ECOLOGICAL IDENTITY: BECOMING A REFLECTIVE ENVIRONMENTALIST* 78 (1996) (“These controversies are critical to environmental politics: the boundaries of ownership, decisions about common property resources, the juxtaposition of the public good and private property rights. The environmentalist calls attention to the ecological ramifications of decisions about property.”).

¹⁶⁸ DAVID W. PEARCE & R. KERRY TURNER, *ECONOMICS OF NATURAL RESOURCES AND THE ENVIRONMENT* 302 (1990) (explaining that “[b]ecause of the multifunctionality of such environmental assets,” such as wilderness areas or national parks, “resource extraction can, for example, mean the direct loss of landscape quality and both direct and indirect ecological damage via pollution”).

¹⁶⁹ THOMASHOW, *supra* note 167, at 78.

article, but it is one that should logically follow a determination of what rights will be granted, who can own the rights, and how the owners must go about obtaining and maintaining those rights. This determination would create a framework that must be established before effective environmental regulations could be implemented.

The other major argument against the Mining Law is that it does not provide the government with a royalty or payment beyond the modest fees paid if a resource is located.¹⁷⁰ Many view the Mining Law as permitting the government to give away valuable minerals.¹⁷¹ However, others contend that these property rights are "not given away for nothing; they are awarded based on effort in locating the minerals."¹⁷² These locating costs are considerable, and as mentioned above, the government can shift these costs to private sector investors who would be willing to expend these costs in exchange for the ability to retain some sort of right in what they extract, thereby ensuring that their efforts are not fruitless. The low initial transfer fee is part of the uniqueness of the Mining Law and why it is so effective.¹⁷³

No matter what property right acquisition model is implemented, the base expense of locating the minerals would remain constant for investors.¹⁷⁴ They would have to expend the same amount on the technology, equipment, and manpower necessary to travel to a mining site to prospect and eventually extract the asteroid's resources. The expenses that do shift depending on the model implemented are the transaction costs. Thus, the higher the transaction cost, the lower the incentive would be to invest.¹⁷⁵ For example, if the property right law requires the investor to give 25% of the extracted resources to the government or enforces expensive licensing fees, these regulations would shift the costs up and the incentive to undertake the project down. Where the initial investment and risk are very large, such as in mining asteroids, additional costs would weigh

¹⁷⁰ Morriss et al., *supra* note 20, at 756.

¹⁷¹ *Id.* at 758; see also RASBAND ET AL., *supra* note 13, at 125 (citing Margaret Kriz, *Mine Games*, 26 NAT'L J. 1669 (1994)) ("The most prominent recent patent was one issued in 1994 to Barrick Goldstrike Mines for a gold mine in Nevada. For just under \$10,000, Barrick received title to about 2000 acres of the public domain, containing an estimated \$11.5 billion in gold.").

¹⁷² Morriss et al., *supra* note 20, at 758.

¹⁷³ *Id.*

¹⁷⁴ *Id.* at 754.

¹⁷⁵ *Id.*

heavily in the decision to pursue these investments. Thus, the most effective models would limit those additional costs.

The Mining Law has very low transaction costs, making it the most effective model for encouraging the necessary initial investment. Its low transaction costs encourage not only investment, but also the strong certainty of the issuance of a claim. Thus, the prospect of obtaining a defined property right if valuable minerals are found further incentivizes investors. Once initial investment costs create less of a barrier to entry, it may be appropriate to choose a different model that creates more income for the government. However, that would be ineffective at this juncture, where barriers to entry are very high.

Eventually, the concerns about environmental impact and lack of royalty payments to the government may become too strong and could require implementation of a different model than the Mining Law.¹⁷⁶ However, the strengths of the Mining Law currently outweigh these concerns, thus supporting the conclusion that it would be a very effective model when applied to asteroid mining.

As mentioned above, the Mining Law has very low transaction costs, making it essentially self-executing. It offers “an important model for governments looking for the means to privatize public property where the value of the property is unknown.”¹⁷⁷ This makes it one of the strongest models for encouraging extraction of resources where there are high costs and risks in the process of finding and extracting those resources, such as in the case of asteroid mining, while only granting select property rights.¹⁷⁸ Former Interior Secretary Donald Hodle called these property rights

“the heart and soul” of the Mining Law—the principle of self-initiated free access to mineral resources and the provision of full title to both mineral and surface estates for minimal transfer fees—provides a rational basis for allocating resources in a prin-

¹⁷⁶ See *id.* at 758.

¹⁷⁷ See *id.* at 751–52 (explaining that the model might work for “[n]ot just mineral rights but assets such as radio spectrum frequencies” and that the “Mining Law can serve as a model for privatization of such resources both here and abroad”).

¹⁷⁸ This aligns with the basic principles of a cost-benefit analysis. Where transaction costs are too high and there are already significant barriers to entry, the costs will outweigh the benefits and investors will not desire to proceed. However, where the transaction costs are low in exchange for an added benefit—in this case the security of a limited monopoly in the minerals found within the territory—an incentive will be created to overcome the barriers to entry.

cipled manner that solves critical information and incentive problems inherent in public ownership of resources.¹⁷⁹

Many of those who oppose reform of the Mining Law argue that regulatory interpretations of the existing law are sufficient to address its significant problems.¹⁸⁰ They argue that there is no need to change the base model for the effective disposition of property rights as an incentive to cultivate valuable resources.¹⁸¹ The effectiveness of this base model and the incentive it creates make the law applicable as an operational property right scheme to incentivize asteroid mining, which is why an asteroid mining law should be modeled after the Mining Law.

V. A PROPOSED ASTEROID MINING LAW MODELED AFTER THE GENERAL MINING LAW OF 1872

Not only is the general base model provided by the Mining Law a solid model for an asteroid mining law, but each section of the law also addresses an important feature that can be implemented into an asteroid mining law. Accordingly, this section takes the analogy beyond the broad strokes and explains how the specific sections of the Mining Law can be applied and adapted to asteroid mining. A section-by-section analysis of each applicable section of the Mining Law will be accompanied by brief explanations of how the law would have to be adapted to asteroid mining. This section then addresses some additional considerations that would need to be taken into account, such as a provision for mining minerals and using them while in space instead of returning them to Earth. Finally, this section concludes with an analysis of the agency involvement that would be required.

A. APPLICATION OF EACH RELEVANT SECTION OF THE GENERAL MINING LAW OF 1872

The most effective way to analogize the Mining Law to an asteroid mining statutory regime is to reflect upon how each key component of the Mining Law is applicable to the different environment of outer space. Each section below will identify a key component of the Mining Law and propose a parallel section that would be applicable to asteroid mining.

¹⁷⁹ Morriss et al., *supra* note 20, at 751 (citing DONALD P. HODEL, INTRODUCTION TO THE MINING LAW OF 1872: A LEGAL AND HISTORICAL ANALYSIS xi (1989)).

¹⁸⁰ RASBAND ET AL., *supra* note 13, at 1082.

¹⁸¹ *Id.*

1. *Lands Open to Purchase by Citizens*

The Mining Law section dealing with lands open to purchase by citizens is found in 30 U.S.C. § 22, which made “all valuable mineral deposits in lands belonging to the United States . . . free and open to exploration and purchase, and the lands in which they are found to occupation and purchase.”¹⁸² This opened up the public domain “to all for the exploitation of our national mineral wealth.”¹⁸³ Only citizens can explore and purchase, subject to “the local customs or rules of miners in the several mining districts,” as long as those customs or rules are not inconsistent with federal law.¹⁸⁴

The most applicable part of this section for mining asteroids is the part that makes the land “‘free and open to exploration’” and “occup[ation].”¹⁸⁵ A necessary component of this section requires a determination that asteroids are in the public domain;¹⁸⁶ however, that is beyond the scope of this article.¹⁸⁷ Supposing that asteroids can be placed in the public domain, the corresponding section of an asteroid mining law would place asteroids in the global public domain for all to explore and physically occupy. This could potentially be accomplished by granting statutory protection to those occupying the land in a codification of the principle of *pedis possessio*, discussed below.¹⁸⁸

As the Mining Law is subject to local customs and rules, the asteroid mining law would be subject to international law, such as the Convention on International Liability for Damage Caused by Space Objects (Liability Convention of 1972), which imposes absolute liability on a state for any damage its spacecraft cause on the Earth’s surface or to other objects in flight.¹⁸⁹ An assur-

¹⁸² 30 U.S.C. § 22 (2012).

¹⁸³ BAKKEN, *supra* note 138, at 9; *see also* 30 U.S.C. § 22.

¹⁸⁴ 30 U.S.C. § 22.

¹⁸⁵ BAKKEN, *supra* note 138, at 9.

¹⁸⁶ Public domain lands are “lands that have been held by the federal government since they became part of the United States.” RASBAND ET AL., *supra* note 13, at 1084.

¹⁸⁷ Whether asteroids are in the public domain is beyond the scope of this article because it would require a detailed analysis of international law. Many authors have discussed the variety of international issues that come with defining property rights in space. *See, e.g.*, Listner, *supra* note 9, at 94; Zullo, *supra* note 43, at 2416–17.

¹⁸⁸ The *pedis possessio* doctrine is defined as “[t]he principle that a prospector working on land in the public domain is entitled to freedom from fraudulent or forcible intrusions while actually working on the site.” BLACK’S LAW DICTIONARY 1246 (9th ed. 2009).

¹⁸⁹ Listner, *supra* note 9, at 83.

ance that the property right would be limited to rights in the minerals, instead of pre- or post-extraction ownership of any surface right, would likely be more acceptable to the international community as a means of obtaining a property right to space resources.¹⁹⁰ This ownership of the mineral rights would provide enough “sticks” out of the property right “bundle” to give adequate assurance and incentive to those investing in these ventures.

2. *Locators’ Rights of Possession and Enjoyment*

The Mining Law section dealing with locators’ rights of possession and enjoyment is 30 U.S.C. § 26, which provides the locators of mineral claims “with exclusive use and enjoyment of their claim plus extralateral rights.”¹⁹¹ So long as the locators do not have adverse claims, they will have the “exclusive right of possession and enjoyment of all the surface” within the location.¹⁹² Section 26 continues on with more details on handling claims and their potential interference with surface claims owned or possessed by others.¹⁹³

As mentioned above, the right to possession and enjoyment of the claim would be a crucial factor in incentivizing the mining of asteroids. Thus, so long as there are no adverse claims, a locator who identifies a valuable mineral source on an asteroid would be given certainty and security in his ability to reap the profits from his great investment in locating and mining the source. Due to the unique nature of asteroids as hundreds of pre-separated territories, the entire portion of section 26 detailing extralateral rights and avoiding interference with the rights of others would not be as necessary in an asteroid mining law if

¹⁹⁰ Many articles express the international community’s concerns over allowing sovereignty in space and how existing international treaties should be handled and interpreted. See, e.g., John Adolph, Comment, *The Recent Boom in Private Space Development and the Necessity of an International Framework Embracing Private Property Rights to Encourage Investment*, 40 INT’L LAW. 961, 962 (2006); Wayne N. White, Jr., *Real Property Rights in Outer Space*, 40 INT’L INST. SPACE L. 370, 371 (1997). Further discussion of these concerns is beyond the scope of this article; however, it is necessary to acknowledge that the asteroid mining law would need to take into account preexisting international agreements.

¹⁹¹ BAKKEN, *supra* note 138, at 10.

¹⁹² *Id.*

¹⁹³ 30 U.S.C. § 26 (2012). The additional details include limitations on the size of the right of possession with respect to veins, lodes, and ledges within the land. *Id.* Due to the unique environment on asteroids, many of these additional details would not be as applicable in an asteroid mining law.

the claims are allowed per asteroid.¹⁹⁴ Again, establishment of a right to possess and utilize the territory is crucial to assure miners that they would be able to reap the profits from their investment without others interfering with those rights.

3. *Limits on the Size of a Claim and Abandonment of a Right*

The Mining Law section explaining the limits on the size of claims and the abandonment of rights is 30 U.S.C. § 27, which addresses some of the problems of subterranean exploration for valuable minerals. An asteroid mining law could grant a property right in which an individual owner would have rights to an entire asteroid or multiple claims on each asteroid. However, the problem of having to limit the size of a claim could be entirely avoided by only allowing each asteroid to be subject to one claim. But some asteroids are very large and may warrant multiple claims.¹⁹⁵ The existing law essentially provides that once tunnels are commenced and a claim is being prosecuted, the owner of the tunnel holds the right to possession of all veins or lodes within 3,000 feet of the tunnel.¹⁹⁶ This type of provision could be applied if it is decided that claims will not be isolated by asteroid.

Section 27 also requires claims to continue to be prosecuted, with failure to do so possibly resulting in abandonment.¹⁹⁷ An abandonment provision would be very relevant to an asteroid mining law. Once the technology develops, there is likely to be more competition among private entities in prospecting and

¹⁹⁴ BAKKEN, *supra* note 138, at 10. Because it is nearly impossible to have one territory here on Earth that will not touch or impact another—with the exception of lands adjacent to bodies of water—section 26 also provides a more detailed description of the extent of the locators' extralateral rights to ensure that those rights do not allow a locator "to enter upon the surface of a claim owned or possessed by another." *Id.* As discussed later, if multiple claims are allowed on each asteroid, more provisions like this one will be necessary. However, this issue of interfering with another's surface claim could be almost entirely avoided by allowing only one claim per asteroid.

¹⁹⁵ Currently, the largest asteroid measured is orbiting beyond Neptune and has a diameter of one Ceres, or 948 kilometers. *Solar System Dynamics: Asteroids*, *supra* note 51. Based on images collected from the Hubble Space Telescope, astronomers believe that this asteroid, which is about the size of Texas, "could contain more fresh water than Earth." Bjorn Carey, *Largest Asteroid Might Contain More Fresh Water than Earth*, SPACE (Sept. 7, 2005), <http://www.space.com/1526-largest-asteroid-fresh-water-earth.html>.

¹⁹⁶ 30 U.S.C. § 27.

¹⁹⁷ *Id.*

staking claims on asteroids.¹⁹⁸ Having a clear provision that these claims must continuously be prosecuted would be necessary to ensure that companies do not hoard claims and sit on their rights. Allowing claims to be hoarded would be contrary to highest and best use principles and would allow the monopoly granted to the entity to go beyond what the law allows. The primary practical adjustments to such a requirement might be in the window of required prosecution. The six-month window provided in the Mining Law is likely too short a time period, for now, in the context of space mining.¹⁹⁹

4. Standards for Mining

The Mining Law section that discusses standards for mining is 30 U.S.C. § 28, which “set[s] national standards for some aspects of mining.”²⁰⁰ Congress set minimum federal standards: the location must be distinctly marked, and records must be kept with names of locators, date of location, description of claims, etc.²⁰¹ The minimum work requirement to maintain a claim was set at \$100 worth of labor.²⁰² This is the assessment-fee provision that was “designed to ensure that claimants who failed to diligently work their claims would forfeit their rights.”²⁰³ It set a measure to the requirement that a claim must be prosecuted or it will be abandoned.²⁰⁴

While the \$100 labor requirement might appear to be a *de minimis* amount, it serves the important purpose of making sure claimants do not sit on their claims and gives a measurable rule to apply in determining when the claim is not being prosecuted.²⁰⁵ A similar requirement in an asteroid mining law might provide that some *de minimis* amount of labor be expended, such as launching a spacecraft for the purpose of conducting mining within a certain number of years after a successful prospecting mission returns with data supporting the existence of valuable minerals, or mandating that a claim is determined

¹⁹⁸ One of the desirable results of a law to incentivize mining is an increase in competition. Greater competition would result in more efforts to mine and more productivity. JAMES D. GWARTNEY ET AL., *ECONOMICS: PRIVATE AND PUBLIC CHOICE* 338 (12th ed. 2009).

¹⁹⁹ 30 U.S.C. § 27.

²⁰⁰ BAKKEN, *supra* note 138, at 10.

²⁰¹ *Id.*

²⁰² 30 U.S.C. § 28.

²⁰³ RASBAND ET AL., *supra* note 13, at 1103.

²⁰⁴ *See* 30 U.S.C. § 28.

²⁰⁵ *See id.*

abandoned if the company can no longer financially support the mission.²⁰⁶ These measures would be for the sole purpose of ensuring that a claim is pursued with diligence, like the requirement in the Mining Law that \$100 of labor be annually expended.²⁰⁷

5. Fees

In the Mining Law, the fee for maintaining a claim is \$100 a year.²⁰⁸ Congress recently added a \$25 claim location fee for first-time locators.²⁰⁹ In addition to these fees, applicants pay for the surveying fees and publication costs of their patents.²¹⁰ The fees are paid to the Bureau of Land Management (BLM),²¹¹ and failure to pay the fees results in forfeiture of the unpatented claim.²¹² Like the requirement for amount of labor expended, these fees might also appear to be *de minimis*.²¹³ However, as mentioned above, they reflect a model that brings with it very low transfer costs, which is an important feature where the goal of a statute is to encourage development of something that has a large initial investment cost.²¹⁴

A claim maintenance fee in an asteroid mining law could also be very modest, if not *de minimis*.²¹⁵ The claim fee would not be the main benefit received by the government from a venture; rather, the increase in national wealth and GDP would be the primary benefit.²¹⁶ A reflection of the true administrative costs involved in filing a claim could be considered in determining the claim maintenance costs. Thus, this fee could help fund an asteroid-management bureau designed to track the surveys, record claims, and collect fees. As discussed further below, this asteroid-management bureau would play a very similar role to

²⁰⁶ *See id.*

²⁰⁷ *See id.*

²⁰⁸ *Id.* § 28f(a)(1).

²⁰⁹ *Id.* § 28g.

²¹⁰ BAKKEN, *supra* note 138, at 14.

²¹¹ 30 U.S.C. § 28l.

²¹² *Id.* § 28i.

²¹³ *See id.* §§ 28f(a)(1), 28g.

²¹⁴ *See id.* The initial investment is a constant in the developer's project; the transfer fee is adjustable, and where that fee is low and certain to result in the attainment of a property right in valuable resources, the investor would be more likely to diligently pursue his investment. *See supra* notes 173–75 and accompanying text.

²¹⁵ *See* 30 U.S.C. § 28f(a)(1).

²¹⁶ These are positive externalities where the social benefit is not reflected by the market price. RASBAND ET AL., *supra* note 13, at 42.

the role of the BLM in the Mining Law.²¹⁷ The overall focus of this section in the asteroid mining law should reflect the focus of the Mining Law, which is not to collect revenue for the government but to ensure the accuracy of claims and allow for a single management system to avoid and handle adverse claims, as well as to manage the issuance of patents.

6. *Obtaining Patents*

The Mining Law section that describes the process of obtaining patents is 30 U.S.C. § 29, which discusses, among other things, the procedures for procuring a patent, posting notice of a claim, publishing the notice, addressing adverse claims, and paying for a claim.²¹⁸ Issuing a patent converts a claim to private property, thus extinguishing the government's title to, and rights to collect revenue on, the extracted minerals.²¹⁹ The claimant has the option of filing for fee simple ownership of just the mineral rights or of both the mineral and surface rights.²²⁰ The government can still tax the property or impose income taxes on the economic activity generated from the property.²²¹

The patent process begins with the claimant filing an application, under oath, in the proper land office.²²² The applicant must also

post a copy of [the] plat, together with a notice of such application for a patent, in a conspicuous place on the land embraced in such plat previous to the filing of the application for a patent, and shall file an affidavit of at least two persons that such notice has been duly posted.²²³

²¹⁷ See 30 U.S.C. § 28*l*.

²¹⁸ *Id.* § 29.

²¹⁹ Morriss et al., *supra* note 20, at 757–58 (“These requirements simply ensure that any other potential claimant has notice that the land is about to be privatized, that there is indeed a valuable mineral resource present, and that the boundaries of the claimed area are settled in advance.”).

²²⁰ *Id.* at 756.

²²¹ *Id.* at 757.

²²² 30 U.S.C. § 29.

²²³ *Id.*; see also BAKKEN, *supra* note 138, at 14 (“In [S]ection 13[.], Congress provided that affidavits required by the statute could be verified by ‘any officer authorized to administer oaths with the land-district where the claims may be situated.’ So, too, testimony and proofs could be similarly taken.”).

A copy of this affidavit is filed with the state BLM office.²²⁴ The application also needs to include a mineral survey, which the applicant must request from a surveyor approved by the BLM.²²⁵

The surveyor submits the results to the state BLM office and provides a copy to the applicant, who then must post a copy of the claim and notice of intent to seek a patent with the state BLM office and publish a copy in the local newspaper for at least sixty days.²²⁶ During these sixty days, the applicant must register a certificate with the Director of the BLM that will “be incorporated in the patent” and states that “\$500 worth of labor has been expended or improvements [have been] made upon the claim” and that “the plat is correct.”²²⁷ After the sixty days expire, the applicant must file another affidavit “showing that the plat and notice have been posted in a conspicuous place on the claim” during the sixty-day publication period.²²⁸ If no adverse claim is filed by this time, the applicant receives a patent upon payment of \$5 per acre.²²⁹

Such a low-cost patenting process would be very effective for staking a claim on an asteroid.²³⁰ The publication period would ensure that notice is provided to the world so as to minimize adverse claims.²³¹ As further discussed below, designating a single bureau to manage the survey and recordation system would ensure that the claims are properly measured and maintained.²³² Again, it would probably be most effective in the international context to limit patents to mineral rights and refuse to allow surface ownership in fee simple.²³³

²²⁴ 30 U.S.C. § 29.

²²⁵ *Id.* §§ 29, 39; 43 C.F.R. § 3861.5-1 to -2 (2012).

²²⁶ 30 U.S.C. § 29; 43 C.F.R. § 3861.3-1. During these sixty days, the claimant also needs to file a certificate with the Director of the BLM “that \$500 worth of labor has been expended or improvements made upon the claim,” and that the plat is correct. 30 U.S.C. § 29. After sixty days, “the claimant shall file his affidavit, showing that the plat and notice have been posted in a conspicuous place on the claim during” the publication period. *Id.*

²²⁷ 30 U.S.C. § 29.

²²⁸ *Id.*

²²⁹ *Id.*

²³⁰ *See id.*

²³¹ *See id.*

²³² *See id.*

²³³ *See* Morriss et al., *supra* note 20, at 756.

7. Land Surveys, Recordation, and Adverse Conflicting Claims

Several sections of the Mining Law address the procedures for processing claims, surveying lands, recording claims, and resolving adverse and conflicting claims.²³⁴ The primary sections are section 34, which provides the survey requirements and recordation process with the BLM,²³⁵ and section 30, which discusses the process for disputing adverse claims.²³⁶ The process of surveying claims, recording claims, and disputing adverse claims all heavily involve the BLM.²³⁷

Under section 34, claims on “surveyed lands shall designate the location of the claims with reference to the lines of the public survey, but need not conform therewith.”²³⁸ Where patents were issued or will be issued on unsurveyed lands, the Director of the BLM extends the public survey and adjusts the boundaries of the public survey so that there is no conflict with the claims.²³⁹ This is where the BLM comes in to ensure that there is greater certainty in property descriptions.²⁴⁰

The creation of a bureau similar to the BLM to manage asteroid claims would be necessary to track and maintain the accuracy of property claims.²⁴¹ Presently, a number system is used to track the hundreds of thousands of near-Earth objects, including asteroids.²⁴² Thus, if claims are limited to one claim per asteroid, the existing number-tracking system could be used.²⁴³ However, a different surveying system, similar to the one used

²³⁴ 30 U.S.C. §§ 34, 37–41.

²³⁵ *Id.* § 34.

²³⁶ *Id.* § 30.

²³⁷ The BLM is an agency within the Department of the Interior that administers America’s public lands. *The Bureau of Land Management: Who We Are, What We Do*, U.S. DEP’T INTERIOR BUREAU OF LAND MGMT., <http://www.blm.gov/wo/st/en/prog/planning.html> (last updated Jan. 26, 2012).

²³⁸ 30 U.S.C. § 34.

²³⁹ *Id.*

²⁴⁰ BAKKEN, *supra* note 138, at 12.

²⁴¹ *See id.*

²⁴² *Provisional Designations*, MINOR PLANET CENTER, <http://www.minorplanetcenter.org/iau/lists/Designs.html> (last visited Mar. 7, 2013). The Minor Planet Center “is responsible for the designation of minor bodies in the solar system[, including] minor planets [and] comets,” and “for the collection, computation, checking[,] and dissemination of astrometric observations and orbits for minor planets, comets, and natural satellites.” MINOR PLANET CENTER, <http://www.minorplanetcenter.net/> (last visited Mar. 7, 2013). It applies a provisional designation number system for tracking each discovered near-Earth object. *Provisional Designations*, *supra*.

²⁴³ *See Provisional Designations*, *supra* note 242.

under the Mining Law through the BLM, might prove effective if multiple claims are allowed for each asteroid.²⁴⁴ Either way, it will be important to establish a clear means of recording claims and a central bureau for tracking those claims because an error in recordation could result in millions of dollars wasted.

Section 30 provides the procedure for situations when an adverse claim is filed during the period of publication.²⁴⁵ The statute places the burden of proof on the adverse claimant.²⁴⁶ It requires the adverse claimant to commence court proceedings within thirty days of filing his claim, with the failure to do so resulting in a waiver of the adverse claim.²⁴⁷ This is where the other major entity in the process of handling claims comes in: the Interior Board of Land Appeals (IBLA).²⁴⁸ The IBLA is one of the primary forums of independent and objective administrative review of BLM decisions.²⁴⁹ After a decision is rendered from the proceeding, the prevailing party must record the judgment with the land office registry and follow the remaining procedures for patenting the claim with the Director of the BLM.²⁵⁰

As mentioned above, the statute calls for lines to be "marked, defined, and established upon the ground by the monuments of the official survey upon which the patent grant is based."²⁵¹ These monuments "constitute the highest authority as to what land is patented," and where there is a dispute among patented claims, "the monuments on the ground shall govern."²⁵² It might be difficult to put a marker on an asteroid; however, it would certainly be an indication of who owns the patent.²⁵³ Due to advances in the availability of sophisticated charting technology, it might be sufficient to rely on the official recording services.²⁵⁴ This would be especially true if a system of one patent

²⁴⁴ See 30 U.S.C. § 34.

²⁴⁵ *Id.* § 30.

²⁴⁶ *Id.*

²⁴⁷ *Id.*

²⁴⁸ David L. Hughes, *Practice and Procedure Before the Interior Board of Land Appeals*, 14 PUB. LAND L. REV. 113, 116 (1993).

²⁴⁹ *Id.* ("The IBLA, acting independently of the Solicitor [of Labor] and the BLM, reviews the legality of BLM's final decisions . . .").

²⁵⁰ 30 U.S.C. § 30.

²⁵¹ *Id.* § 34.

²⁵² *Id.*

²⁵³ See *id.*

²⁵⁴ See *Provisional Designations*, *supra* note 242. Technology has greatly advanced since the Mining Law was first enacted and land was still surveyed by hand. See *id.* Today, the provisional designation system for tracking near-Earth objects is very detailed and extensive. See *id.*

per asteroid is implemented.²⁵⁵ However, even if a system of multiple claims per asteroid is implemented, electronic tracking technology, such as that used in charting the asteroids themselves, would likely be sufficient to denote individual claims.²⁵⁶ The most relevant part of resolving disputed claims would be implementation of an independent appeals board like the IBLA.²⁵⁷ Because of the high investment costs, it would be especially important to have an independent board from the recordation bureau to review disputed claims.²⁵⁸

8. *Patents for Nonmineral Lands*

The Mining Law section dealing with patents for nonmineral lands is 30 U.S.C. § 42.²⁵⁹ Section 42 addresses “milling and other adjunct mining usages of the public lands.”²⁶⁰ A locator of a vein or lode could include nonmineral land not contiguous to the mineral land in the application for the purpose of “milling, processing, beneficiation, or other operations in connection with [a] claim.”²⁶¹

This section is applicable to asteroid mining in several ways. It can be used to establish the ancillary rights necessary to conduct the mining itself, such as rights to traverse the different levels of atmosphere.²⁶² This section can also be used to establish the rights to process minerals in space (before bringing them back to Earth) and conduct *in-situ* resource utilization.²⁶³

Without ancillary rights, the primary right to explore, mine, and trespass upon the asteroid would be meaningless. Ancillary rights in this context include the right to access the asteroid and utilize the surface to the extent necessary to support the mining operation.²⁶⁴ Inserting these rights preemptively into the aster-

²⁵⁵ See *id.*

²⁵⁶ See *Minor Planet Center & the Tamkin Foundation*, MINOR PLANET CENTER, <http://www.minorplanetcenter.net/iau/ACK/TamkinFoundation.html> (last visited Mar. 7, 2013).

²⁵⁷ See Hughes, *supra* note 248, at 116.

²⁵⁸ See *id.*

²⁵⁹ 30 U.S.C. § 42 (2012).

²⁶⁰ BAKKEN, *supra* note 138, at 14.

²⁶¹ 30 U.S.C. § 42(b).

²⁶² See *id.* Ancillary rights, in this context, are secondary rights that are necessary to give the primary right meaning. See *id.*

²⁶³ See *id.*

²⁶⁴ This might include non-mining-related activities, like establishing a temporary living environment for miners or building a processing plant, which may fall outside of the scope of the right granted to access the surface land when conducting the subsurface mining. See Clayton J. Parr, *Acquisition and Exercise of Rights*

oid mining law would be more effective than requiring miners to acquire these ancillary rights through independent means, such as by obtaining a separate license for access through the various levels of atmosphere to get to the asteroids.

Using section 42, the right to process minerals in space and the right to conduct *in-situ* resource utilization would also be more effective if established preemptively.²⁶⁵ Processing certain minerals might be more feasible in space because the low-gravity environment that space provides makes the transportation of large objects significantly easier than on Earth.²⁶⁶ *In-situ* resource utilization in this context would mean processing and using resources completely in space instead of on Earth.²⁶⁷ “*In-situ* resource utilization will enable the affordable establishment of extraterrestrial exploration and operations by minimizing the materials carried from Earth and by developing advanced, autonomous devices to optimize the benefits of available *in-situ* resources.”²⁶⁸ Water, fuel, metal structures, and other essentials for commercial operations in outer space could be produced completely in space.²⁶⁹

Overall, each section of the Mining Law has some applicability to an asteroid mining law, making the Mining Law a functional base model. However, the unique environment of space, both physically and as an international territory, would call for some additional considerations.

B. ADDITIONAL NECESSARY CONSIDERATIONS UNIQUE TO AN ASTEROID MINING LAW

It is important to recognize that the Mining Law would obviously not cover each unique feature of an asteroid mining law. The Mining Law would serve as a base model. Many additional

to Use Land in Connection with Surface Mining Operations, in *SURFACE MINING* 273 (Bruce A. Kennedy ed., 2d ed. 1990) (recognizing that “[o]ften, the operator already holds most of the needed lands through mining claims or mineral leases,” but where they do not have the necessary rights to conduct their mining operations, “independent methods of land acquisition must be utilized”).

²⁶⁵ See 30 U.S.C. § 42.

²⁶⁶ See ZUBRIN, *supra* note 57, at 146.

²⁶⁷ *About In-Situ Resource Utilization (ISRU)*, NASA, <http://www.nasa.gov/exploration/analogs/isru/> (last updated Aug. 21, 2012). *In-situ* resource utilization is the “practice of harnessing resources at the exploration site.” *Id.*

²⁶⁸ *Ames Technology Capabilities and Facilities: In-Situ Resource Utilization*, NASA, http://www.nasa.gov/centers/ames/research/technology-onepaggers/in-situ_resource_Utiliza14.html (last updated Mar. 29, 2008).

²⁶⁹ See *id.*

factors would need to be considered in forming an asteroid mining law. Two of the more obvious additional considerations are a provision codifying the common-law doctrine of *pedis possessio*²⁷⁰ and a more detailed definition of the scope of minerals covered by the asteroid mining law.

The doctrine of *pedis possessio* is the "principle that a prospector working on land in the public domain is entitled to freedom from fraudulent or forcible intrusions while actually working on the site."²⁷¹ The Mining Law "does not define a prospector's rights during the exploration period before he actually discovers minerals; pre-discovery rights are governed by the state common law doctrine of *pedis possessio*."²⁷² Claimants acquire rights under this doctrine by diligently working their claims and actually occupying the land.²⁷³ Since entities seeking to stake claims in asteroids may come from countries that do not recognize the doctrine of *pedis possessio*, it would be helpful, if not necessary, to codify this doctrine in the asteroid mining statute.

Furthermore, some consideration would need to be given to the scope of the asteroid mining statute, including which minerals would be granted rights under it. While the Mining Law focuses on "valuable minerals," some broader definition may be more appropriate to accommodate the different necessities for

²⁷⁰ RASBAND ET AL., *supra* note 13, at 1119-20.

Those who, being qualified, proceed in good faith to make such explorations and enter peaceably upon vacant lands of the United States for that purpose are not treated as mere trespassers, but as licensees or tenants at will. For since, as a practical matter, exploration must precede the discovery of minerals, and some occupation of the land ordinarily is necessary for adequate and systematic exploration, legal recognition of the *pedis possessio* of a bona fide and qualified prospector is universally regarded as a necessity. It is held that upon the public domain a miner may hold the place in which he may be working against all others having no better right, and while he remains in possession, diligently working towards discovery, is entitled at least for a reasonable time to be protected against forcible, fraudulent, and clandestine intrusions upon his possession.

Id. (quoting *Union Oil Co. of Cal. v. Smith*, 249 U.S. 337, 346-47 (1919)).

²⁷¹ BLACK'S LAW DICTIONARY, *supra* note 188, at 1246.

²⁷² James M. Finberg, Comment, *The General Mining Law and the Doctrine of Pedis Possessio: The Case for Congressional Action*, 49 U. CHI. L. REV. 1026, 1027-28 (1982) (Today, *pedis possessio* rights are "generally deemed to extend to the boundaries of the claim a prospector is working, so long as the claim is clearly staked.").

²⁷³ Morriss et al., *supra* note 20, at 756.

in-situ space mining and to incentivize extraction in space.²⁷⁴ The definition of what constitutes a valuable mineral may need to be broader to take into account volatiles and other metals used in processing minerals while in space.²⁷⁵

Again, these examples of additional factors that would need to be considered are only a few of the many that would need to be considered in adapting the base model provided by the Mining Law to an asteroid mining law.

C. THE REGULATORY AGENCY

Another consideration to take into account is the need to implement a regulatory authority to enforce the asteroid mining law. In the United States, NASA is best suited to be the primary regulatory agency for asteroid mining. NASA already has regulatory jurisdiction over space ventures.²⁷⁶ It also retains space commercialization as one of its primary goals and has already made considerable efforts toward partnering with private companies in commercializing space.²⁷⁷

Creating a new subagency under NASA could be an effective means for working with the other necessary existing agencies, such as the FAA, toward creating licensing requirements.²⁷⁸ Thus, it would be prudent to ensure that the new subagency's authority and jurisdiction cover such responsibilities and recognize these interactions, or possibly provide alternative measures to avoid cross-agency coverage. It would be necessary to create

²⁷⁴ See 30 U.S.C. § 21 (2012). Courts have recognized the malleability of the definition of minerals and that the term is "used in so many senses, dependent upon the context, that the ordinary definitions of the dictionary throw but little light upon its signification in a given case." *N. Pac. Ry. Co. v. Soderberg*, 188 U.S. 526, 530 (1903). A broad definition could include every substance found in land, while a narrow definition could include only precious metals. *Id.* Recognizing that the proposed mining law would have to have some definition of "minerals," the actual boundaries of that definition are beyond the scope of this article. See *id.*

²⁷⁵ See *Soderberg*, 188 U.S. at 530. Case law confining the definition of valuable minerals to exclude resources, such as water, would be inappropriate in the application of a asteroid mining law. See, e.g., *Andrus v. Charleston Stone Prods. Co.*, 436 U.S. 604, 611–14 (1978) (refusing to find that a valuable or marketable mineral existed on a site because of the presence of water and holding that water is not a locatable mineral).

²⁷⁶ 51 U.S.C. §§ 20102, 20111(a), 20112(a)(1).

²⁷⁷ *Id.* § 20102; Press Release, NASA, NASA Signs Commercial Space Transp. Agreements (June 18, 2007), http://www.nasa.gov/home/hqnews/2007/jun/HQ_07138_LOTS_3_unfunded.FAA.

²⁷⁸ See *Licenses & Permits: Commercial Space Transportation*, *supra* note 101.

several international components to the regulatory authority, such as an international recordation bureau similar to the BLM and an international appeals board similar to the IBLA.²⁷⁹ The new NASA subagency would need to have the defined authority and jurisdiction to work with an international recordation bureau and an international appeals board.

A new international recordation bureau, like the BLM, would be required to ensure that claims are properly surveyed and recorded in a central place.²⁸⁰ Also like the BLM, the bureau would be responsible for collecting fees and ensuring that proper notice is published so that the entire world is put on notice of a claim, so as to avoid adverse claims.²⁸¹ An international appeals board would need to be created to handle adverse claims. This appeals board, like the IBLA, should be an independent appeals board aimed at making decisions in a disinterested manner.²⁸²

In sum, the various sections of the Mining Law provide a solid base model for the creation of an asteroid mining law. Obviously, additional considerations—such as the creation of a regulatory authority—would need to be taken into account due to the unique context of outer space. But overall, significant parallels can be drawn between the various features of the Mining Law and an asteroid mining law.

VI. CONCLUSION

Asteroid mining is the new Western Frontier. The ability to carry out commercial asteroid mining ventures to extract large amounts of valuable minerals from the asteroids is close to becoming a reality. The private sector is better funded to carry out such ventures. However, there is no solid structure to define what property rights the private sector could obtain from a successful asteroid mining operation. This structure is necessary to incentivize the private sector to carry out these missions, and the Mining Law is a solid model for an internationally applicable law that would encourage asteroid mining. This is because the Mining Law gives a possessory interest in the minerals contained in the land without granting complete sovereignty. This model also provides for minimal transfer costs in the acquisition of the

²⁷⁹ See 30 U.S.C. §§ 30, 34, 39; Hughes, *supra* note 248, at 116.

²⁸⁰ See 30 U.S.C. § 34.

²⁸¹ See *id.* § 29.

²⁸² See Hughes, *supra* note 248, at 116.

property rights while imposing a requirement that the claim first be determined to contain valuable minerals before recordation.

This limited property right would incentivize private companies to mine asteroids by giving them certainty in what rights they would obtain and security that they would be able to own the minerals and profit from their ventures. Also, this limited property right would avoid international conflicts between private entities claiming sovereignty in celestial bodies. With the implementation of a property-right model like the Mining Law, society can move toward an efficient and profitable new Western Frontier.



Case Notes

